US009304062B2

(12) **United States Patent**
Ruther et al.

(10) **Patent No.: US 9,304,062 B2**
(45) **Date of Patent: Apr. 5, 2016**

(54) **SYSTEM AND METHOD FOR EXTENDING COMMUNICATION RANGE AND REDUCING POWER CONSUMPTION OF VEHICLE DIAGNOSTIC EQUIPMENT**

(71) Applicant: **Snap-on Incorporated**, Kenosha, WI (US)

(72) Inventors: **Timothy G. Ruther**, Carpentersville, IL (US); **Carl J. Krzystofczyk**, Mount Prospect, IL (US)

(73) Assignee: **Snap-on Incorporated**, Kenosha, WI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 82 days.

(21) Appl. No.: **14/022,749**

(22) Filed: **Sep. 10, 2013**

(65) **Prior Publication Data**

US 2014/0019000 A1 Jan. 16, 2014

Related U.S. Application Data

(63) Continuation of application No. 12/859,040, filed on Aug. 18, 2010, now Pat. No. 8,560,168.

(51) **Int. Cl.**
G01M 17/00 (2006.01)
G01M 17/007 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G01M 17/007*** (2013.01); ***B60R 16/0315*** (2013.01); ***G07C 5/008*** (2013.01); ***G07C 5/0825*** (2013.01)

(58) **Field of Classification Search**
CPC B60R 16/0315; H04W 52/24
USPC 701/34.3; 455/522, 574
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,587,079 A 2/1952 Woods et al.
2,680,210 A 6/1954 Miller et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CA 2373157 A1 3/2000
DE 195 43 784 A1 5/2007
(Continued)

OTHER PUBLICATIONS

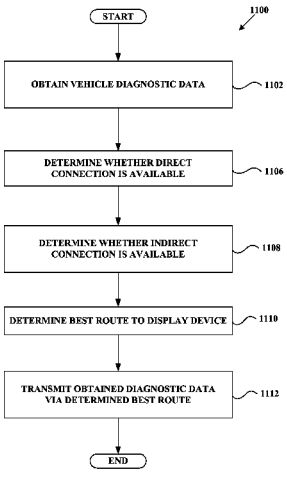
Bluetooth Sig Inc., Bluetooth Specification Version 4.0, vol. 2, "Core System Package [BR/EDR Controller Volume]," Part C "Link Manager Protocol Specification," Section 4.2 "Security", pp. 247-275, Jun. 30, 2010.
(Continued)

Primary Examiner — Hunter Wilder
(74) *Attorney, Agent, or Firm* — McDonnell Boehnen Hulbert & Berghoff LLP

(57) **ABSTRACT**

Disclosed are systems and methods for transmitting obtained vehicle diagnostic data to a separate display device. The method includes a first vehicle diagnostic device obtaining vehicle diagnostic data via a vehicle interface to a diagnostic port of a vehicle, determining whether a direct wireless connection with one or more display devices is available, and determining whether an indirect wireless connection with the one or more display devices is available via a second separate vehicle diagnostic device. Responsive to a further determination, the vehicle diagnostic device may transmit the obtained diagnostic data to the one or more display devices via the second separate vehicle diagnostic device. The further determination may be based on one or more of wireless connectivity status, power level status, transmission power requirements, or other facts or determinations.

21 Claims, 12 Drawing Sheets



(51) **Int. Cl.**

B60R 16/03	(2006.01)
G07C 5/00	(2006.01)
G07C 5/08	(2006.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,058,826	A	11/1977	Schneider
4,072,851	A	2/1978	Rose
4,104,725	A	8/1978	Rose et al.
4,113,980	A	9/1978	Bell
4,257,104	A	3/1981	Martin et al.
4,270,174	A	5/1981	Karlin et al.
4,404,639	A	9/1983	McQuire et al.
4,441,359	A	4/1984	Ezoe
4,602,127	A	7/1986	Neely et al.
4,774,438	A	9/1988	Rogers et al.
4,814,896	A	3/1989	Heitzman et al.
4,853,850	A	8/1989	Krass, Jr. et al.
4,962,456	A	10/1990	Abe et al.
5,157,610	A	10/1992	Asano et al.
5,160,892	A	11/1992	Makhija et al.
5,317,304	A	5/1994	Choi
5,365,436	A	11/1994	Schaller et al.
5,373,458	A	12/1994	Bishay et al.
5,396,168	A	3/1995	Heep et al.
5,417,222	A	5/1995	Dempsey et al.
5,432,904	A	7/1995	Wong
5,442,553	A	8/1995	Parrillo
5,465,207	A	11/1995	Boatwright et al.
5,506,772	A	4/1996	Kubozono et al.
5,507,288	A	4/1996	Bocker et al.
5,521,443	A	5/1996	Imura et al.
5,532,927	A	7/1996	Pink et al.
5,541,840	A	7/1996	Gurne et al.
5,583,912	A	12/1996	Schillaci et al.
5,592,383	A	1/1997	Rogers et al.
5,687,717	A	11/1997	Halpern et al.
5,758,300	A	5/1998	Abe
5,766,020	A	6/1998	Hughes
5,836,666	A	11/1998	Aoyama et al.
5,850,209	A	12/1998	Lemke et al.
5,884,202	A	3/1999	Arjomand
5,899,947	A	5/1999	Hall et al.
5,923,161	A	7/1999	Frankovitch, Jr. et al.
6,021,366	A	2/2000	Fieramosca et al.
6,055,468	A	4/2000	Kaman et al.
6,067,486	A	5/2000	Aragones et al.
6,094,609	A	7/2000	Arjomand
6,134,489	A	10/2000	Smedley
6,140,811	A	10/2000	Little
6,169,943	B1	1/2001	Simon et al.
6,178,527	B1	1/2001	Vidales
6,179,214	B1	1/2001	Key et al.
6,181,563	B1	1/2001	Shimbo et al.
6,188,384	B1	2/2001	Sullivan et al.
6,192,303	B1	2/2001	Takakura et al.
6,195,617	B1	2/2001	Miller
6,222,374	B1	4/2001	Shoemaker
6,294,982	B1	9/2001	Hooks et al.
6,311,138	B2	10/2001	Miller
6,314,422	B1	11/2001	Barker et al.
6,321,151	B1	11/2001	Shultz
6,356,823	B1	3/2002	Iannotti et al.
6,360,551	B1	3/2002	Renders
6,374,315	B1	4/2002	Okada et al.
6,385,300	B1	5/2002	Mohammadian et al.
6,401,049	B1	6/2002	Ehmer
6,416,471	B1	7/2002	Kumar et al.
6,477,478	B1	11/2002	Jones et al.
6,487,478	B1	11/2002	Azzaro et al.
6,609,050	B2	8/2003	Li
6,622,070	B1	9/2003	Wacker et al.
6,640,166	B2	10/2003	Liebl et al.
6,662,123	B2	12/2003	Maeckel et al.
6,693,367	B1	2/2004	Schmeisser et al.
6,711,524	B2	3/2004	Wolf et al.
6,745,151	B2	6/2004	Marko et al.
6,748,335	B2	6/2004	Pickerd
6,757,521	B1	6/2004	Ying
6,778,931	B1	8/2004	Letts et al.
6,789,007	B2	9/2004	Ellis et al.
6,802,032	B1	10/2004	Budinger et al.
6,807,469	B2	10/2004	Funkhouser et al.
6,807,496	B2	10/2004	Pickerd
6,822,639	B1	11/2004	Silverbrook et al.
6,823,243	B2	11/2004	Chinnadurai et al.
6,844,823	B2	1/2005	Hooks et al.
6,847,916	B1	1/2005	Ying
6,873,940	B1	3/2005	Kamatani
6,947,043	B1	9/2005	Klingman et al.
6,957,128	B1	10/2005	Ito et al.
6,959,235	B1	10/2005	Abdel-Malek et al.
6,972,669	B2	12/2005	Saito et al.
6,982,653	B2	1/2006	Voeller et al.
6,988,053	B2	1/2006	Namaky
7,020,546	B2	3/2006	Nagai et al.
7,023,332	B2	4/2006	Saito et al.
7,073,714	B2	7/2006	Namaky et al.
7,124,058	B2	10/2006	Namaky et al.
7,155,321	B2	12/2006	Bromley et al.
7,200,483	B1	4/2007	Kavadeles
7,224,262	B2	5/2007	Simon et al.
7,251,552	B2	7/2007	Schmeisser et al.
7,254,550	B2	8/2007	Reichwein et al.
7,269,482	B1	9/2007	Shultz et al.
7,272,476	B2	9/2007	Ortiz et al.
7,281,663	B2	10/2007	Schmidt et al.
7,294,906	B2	11/2007	Ukaji
7,327,228	B2	2/2008	Min et al.
7,336,082	B1	2/2008	Mofield et al.
7,350,159	B2	3/2008	Cancilla et al.
7,363,129	B1	4/2008	Barnicle et al.
7,383,318	B2	6/2008	Craik
7,444,216	B2	10/2008	Rogers et al.
7,504,926	B2	3/2009	Bessho et al.
7,530,949	B2	5/2009	Al Ali et al.
7,535,466	B2	5/2009	Sampsell et al.
7,580,781	B2	8/2009	Mindeman
7,613,554	B2	11/2009	Rollinger et al.
7,634,337	B2	12/2009	Brozovich et al.
7,648,062	B2	1/2010	Corniot
7,702,437	B2	4/2010	Gilbert
7,711,462	B2	5/2010	Daniels et al.
7,737,860	B2	6/2010	Banta et al.
7,751,955	B2	7/2010	Chinnadurai et al.
8,019,503	B2	9/2011	Andreasen et al.
8,095,261	B2	1/2012	Howell et al.
8,370,018	B2	2/2013	Andreasen et al.
8,412,401	B2	4/2013	Bertosa et al.
8,463,953	B2	6/2013	Davis et al.
8,560,168	B2	10/2013	Ruther et al.
8,670,437	B2	3/2014	Walker et al.
2001/0001850	A1	5/2001	Miller
2002/0007237	A1	1/2002	Phung et al.
2002/0040261	A1	4/2002	Nakamoto et al.
2002/0077780	A1	6/2002	Liebl et al.
2003/0020759	A1	1/2003	Cancilla et al.
2003/0034767	A1	2/2003	Lipscomb et al.
2003/0036832	A1	2/2003	Kokes et al.
2003/0058243	A1	3/2003	Faust et al.
2003/0088346	A1	5/2003	Calkins et al.
2003/0122671	A1	7/2003	Jespersen
2003/0165127	A1*	9/2003	Fujiwara et al. 370/335
2003/0208328	A1	11/2003	Pickerd
2003/0208330	A1	11/2003	Pickerd
2003/0222873	A1	12/2003	Ritter
2004/0054503	A1	3/2004	Namaky
2004/0172177	A1	9/2004	Nagai et al.
2005/0083965	A1	4/2005	Sodergren
2005/0094588	A1*	5/2005	Wentink 370/315
2005/0152294	A1	7/2005	Yu et al.
2005/0157732	A1	7/2005	Joy et al.
2005/0171662	A1*	8/2005	Strege et al. 701/33
2005/0182537	A1	8/2005	Tefft et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2005/0267655	A1	12/2005	Gessner	
2006/0025897	A1	2/2006	Shostak et al.	
2006/0036355	A1	2/2006	Schaar et al.	
2006/0066504	A1	3/2006	Sampsell et al.	
2006/0078175	A1	4/2006	Brozovich	
2006/0095230	A1	5/2006	Grier et al.	
2006/0101311	A1	5/2006	Lipscomb et al.	
2006/0106508	A1	5/2006	Liebl et al.	
2006/0149434	A1	7/2006	Bertosa et al.	
2006/0180371	A1	8/2006	Breed et al.	
2006/0199530	A1*	9/2006	Kawasaki	455/7
2006/0199537	A1	9/2006	Eisenbach	
2006/0212239	A1	9/2006	Letts et al.	
2006/0212540	A1	9/2006	Chon et al.	
2006/0226298	A1	10/2006	Pierson	
2007/0010922	A1	1/2007	Buckley	
2007/0043488	A1	2/2007	Avery et al.	
2007/0072154	A1	3/2007	Akatsuka et al.	
2007/0073459	A1	3/2007	Webster et al.	
2007/0073460	A1	3/2007	Bertosa et al.	
2007/0083307	A1	4/2007	Pasztor et al.	
2007/0100520	A1	5/2007	Shah et al.	
2007/0146133	A1	6/2007	Wehrenberg	
2007/0156311	A1	7/2007	Elcock et al.	
2007/0200550	A1	8/2007	Corredoura	
2007/0244611	A1	10/2007	Brozovich	
2007/0244614	A1	10/2007	Nathanson	
2007/0288134	A1	12/2007	Rollinger et al.	
2007/0290847	A1	12/2007	Harrington et al.	
2007/0294556	A1	12/2007	Wutka	
2008/0003997	A1	1/2008	Parkkinen et al.	
2008/0004764	A1	1/2008	Chinnadurai et al.	
2008/0015748	A1	1/2008	Nagy	
2008/0033609	A1	2/2008	Razavi	
2008/0070501	A1	3/2008	Wyld	
2008/0076389	A1	3/2008	Lee et al.	
2008/0082221	A1	4/2008	Nagy	
2008/0082278	A1	4/2008	Tan et al.	
2008/0103658	A1	5/2008	Boac et al.	
2008/0122288	A1	5/2008	Plante et al.	
2008/0125067	A1	5/2008	Bells et al.	
2008/0140281	A1	6/2008	Morris et al.	
2008/0228344	A1	9/2008	Sampson et al.	
2008/0248748	A1	10/2008	Sangster et al.	
2008/0271107	A1	10/2008	Shioyama et al.	
2008/0319665	A1	12/2008	Berkobin et al.	
2009/0046601	A1*	2/2009	Nordmark et al.	370/255
2009/0125351	A1	5/2009	Davis, Jr.	
2009/0150970	A1	6/2009	Hinds et al.	
2009/0253410	A1	10/2009	Fitzgerald et al.	
2009/0256690	A1	10/2009	Golenski	
2009/0265057	A1	10/2009	Chinnadurai et al.	
2009/0276115	A1	11/2009	Chen	
2009/0288009	A1	11/2009	Dulaney	
2009/0299539	A1	12/2009	Chinnadurai et al.	
2009/0307188	A1	12/2009	Oldham et al.	
2010/0042288	A1	2/2010	Lipscomb et al.	
2010/0076644	A1	3/2010	Cahill et al.	
2010/0100646	A1	4/2010	Park	
2010/0128632	A1	5/2010	Mantysalo	
2010/0179717	A1	7/2010	Gilbert	
2010/0205450	A1	8/2010	Sarnacke et al.	
2010/0289872	A1	11/2010	Funabiki et al.	
2011/0141953	A1	6/2011	Wright et al.	
2011/0153798	A1	6/2011	Groenendaal et al.	
2011/0313593	A1	12/2011	Cohen et al.	
2012/0044052	A1	2/2012	Davis et al.	
2012/0044086	A1	2/2012	Ruther et al.	
2012/0044527	A1	2/2012	Panko	
2012/0044607	A1	2/2012	Loewe	
2012/0045927	A1	2/2012	Panko et al.	
2012/0046807	A1	2/2012	Ruther et al.	
2012/0046825	A1	2/2012	Ruther et al.	
2012/0046826	A1	2/2012	Panko	
2012/0046897	A1	2/2012	Panko	
2012/0047289	A1	2/2012	Krzystofczyk et al.	
2012/0047291	A1	2/2012	Davis et al.	
2012/0047458	A1	2/2012	Alberry et al.	
2012/0047499	A1	2/2012	Krzystofczyk et al.	
2012/0139952	A1	6/2012	Imai et al.	
2012/0215398	A1	8/2012	Chen et al.	
2012/0242510	A1	9/2012	Choi et al.	
2013/0295912	A1	11/2013	Chen	
2013/0297143	A1	11/2013	Chen et al.	

FOREIGN PATENT DOCUMENTS

DE	20 2009 009 035	U1	10/2009
EP	1191498	A1	3/2002
GB	2277807	A	11/1994
GB	2385934	A	9/2003
GB	2405486	A	3/2005
JP	2008233970	A	10/2008
WO	9956201	A1	11/1999
WO	00/34838	A1	6/2000
WO	01/59601	A1	8/2001
WO	0155690	A1	8/2001
WO	0167420	A1	9/2001
WO	0186576	A1	11/2001
WO	2005121814	A1	12/2005
WO	2006008527	A2	1/2006
WO	2006/050454	A2	5/2006
WO	2006055289	A2	5/2006
WO	2006110786	A2	10/2006
WO	2007022426	A2	2/2007
WO	2007038983	A1	4/2007
WO	2007058607	A1	5/2007
WO	2008/043043	A2	4/2008
WO	2008063818	A2	5/2008
WO	2009/137584	A1	11/2009
WO	2009149007	A1	12/2009
WO	2010019771	A1	2/2010

OTHER PUBLICATIONS

Engineer Live, "Ethernet Makes it Way Into the Car," Article date: Jun. 9, 2009, downloaded from the World Wide Web at http://www.engineerlive.com/Design-Engineer/Automotive_Design/Ethernet_makes_its_way_into_the_car/21822/ on Jul. 25, 2011, 4 pages.

OBD-II PIDs, downloaded from the World Wide Web at http://web.archive.org/web/20100329141311/http://en.wikipedia.org/wiki/OBD-II_PIDs, as available on Mar. 29, 2010, 13 pages.

Sorion Electronic Limited, J1962—OBD Diagnostics Connectors, downloaded from World Wide Web at http://www.sorion-group.com/SEL0051_connector.htm on May 24, 2010, pp. 1-3.

Memopad, The OBD2 Cable for Allpro adapter, downloaded from the World Wide Web at http://datawave.commm.com/entry/USB-OBD2-AllPro-adapter, pp. 1-16, Oct. 8, 2008.

Tyco Electronics, Fundamentals of PolySwitch Overcurrent and Overtemperature Devices, pp. 1-13, Sep. 2, 2009.

International Organization for Standardization, ISO TC 22/SC 3, ISO 15031-1:2001(E), Road vehicles—Communication between vehicle and external test equipment for emissions-related diagnostics—Part 1: General information, 36 pages, Aug. 5, 2001.

International Organization for Standardization, ISO TC 22/SC 3 N, ISO/CD 22900-2, Road vehicles, Modular VCI (Vehicle Communication Interface)—Part 2: D-PDU API (Diagnostic Protocol Data Unit Application Programmer Interface), 144 pages, Mar. 31, 2005.

International Organization for Standardization, ISO TC 22/SC 3 N, ISO/CD 22900-1, Road vehicles—Modular Vehicle Communication Interface (MVCI)—Part 1: Hardware design requirements, 29 pages, Mar. 31, 2005.

International Organization for Standardization, ISO TC 22/SC 3 N, ISO/CD 22900-1, Road vehicles—Modular Vehicle Communication Interface (MVCI)—Part 3: D-Server API (Diagnostic Server Application Programmer Interface), 159 pages, Mar. 31, 2005.

International Organization for Standardization, ISO 15031-3:2400(E), Road vehicles—Communication between vehicle and external equipment for emissions-related diagnostics—Part 3: Diag-

(56) **References Cited**

OTHER PUBLICATIONS

nostic connector and related electrical circuits, specification and use—Annex B pp. 17-18, Jul. 2004.
Vital Engineering, Support and Frequently Asked Question regarding the Car-Pal OBD Interface Unit, Jan. 4, 2007, downloaded from the World Wide Web at http://www.vitalengineering.co.uk/support.htm, 8 pages.
Tech Shop Magazine; Snap-on Introduces Verdict Diagnostic and Information System; Aug. 26, 2010; downloaded from the World Wide Web at http://www.techshopmag.com/Controls/PrinterFriendly/PrinterFriendly.aspx, 3 pages.
Snap-On Incorporated, MODIS, Scanner Plug-in User Manual, ZEEMS303L, Rev. A, Aug. 2009, 61 pages.
Snap-On Incorporated, MODIS, Display User Manual, ZEEMS300N, Rev. A, Aug. 2009, 72 pages.
Snap-On Incorporated, MODIS, Component Tests User Manual, ZEEMS308G, Rev. C, Feb. 2009, 52 pages.
Snap-On Incorporated, MODIS, Flexible Gas Analyzer User Manual, ZEEMS306B, Rev. A, Aug. 2009, 47 pages.
Snap-On Incorporated, MODIS, Lab Scope Plug-in User Manual, ZEEMS305K, Rev. C, Feb. 2009, 73 pages.
Metzelaar, R.H.M., Automotive Oscilloscope Applications, Peugeot 205 Holding Back, downloaded from the World Wide Web at http://www.tiepie.com/uk/automotive/GMT/peugot_205_holding_back.html on Jul. 12, 2010, pp. 1-4.
Zussman, Gil et al, Bluetooth Time Division Duplex Analysis as a Polling System, Aug. 19, 2004, 10 pages.
Fluke Corporation, Digital Multimeters, downloaded from the World Wide Web at http://us.fluke.com/usen/products/categorydmm on Jan. 28, 2010, 2 pages.
Fluke Corportation, 233 True=rms Remote Display Digital Multimeter Users Manual, Sep. 2009, 27 pages.
Bluetooth Sig, Inc., Bluetooth Architecture—Data Transport, downloaded from the World Wide Web at http://www.bluetooth.com/KnowledgeCenter/TechnologyOverview/Pages/DateTransport.aspx on May 6, 2010, 8 pages.
Shigeru et al, DL7100 Signal Explorer, A High-Speed Digital Oscilloscope with Long Record Length, Yokogawa Electric Corporation, Yogogawa Technical Report English Edition, No. 30, (2000), 4 pages.
BLUETOMORROW.COM, Bluetooth Pairing, downloaded from the World Wide Web at www.bluetomorrow.com on Apr. 30, 2010, 3 pages.
Snap-On Diagnostics, Snap-on Introduces VERDICT Diagnostic and Information System, Aug. 24, 2010, 2 pages.
Testpath, Inc., Fluke Meter Holsters, downloaded from the World Wide Web at http://www.testpath.com/Categories/Fluke-Meter-Holsters-2220.htm on May 6, 2010, 2 pages.
BMW Canada, Bluetooth Pairing Instructions, Sep. 2009, 10 pages.
Accessory Geeks, Bluetooth Pairing Guides, downloaded from the World Wide Web at http://www.accessorygeeks.com/bluetooth-pairing-guide1.html on Apr. 30, 2010, 2 pages.
Quatech, Inc., Bluetooth Communication Overview, downloaded from the World Wide Web at http:/lwww.quatech.com/support/comm-over-bluetooth.php on May 3, 2010, 3 pages.
Omitec Limited, T4 Diagnostic System, downloaded from the World Wide Web at http://web.archive.org/web/20091119041838/http://www.omitec.com/us/products/diagnostic-testers/t4-diagnostic-system/ as archived on Nov. 19, 2009, 2 pages.
Omitec Limited, Workstations, downloaded from the World Wide Web at http://web.archive.org/web/20100322213801/http://www.omitec.com/us/products/workstation/ as archived on Mar. 22, 2010, 3 pages.
ANOTHERURL.COM, Bluetooth, What is Bluetooth? downloaded from the World Wide Web at http://www.anotherurl.com/library/bluetooth_research.htm on May 17, 2010, 15 pages.
Snap-On Incorporated, EEDM604C, Multimeter, Digital, Automotive, True RMS, Auto Ranging, Hybrid Vehicles, downloaded from the World Wide Web at http://buy1.snapon.com/catalog/item.asp?store=snapon-store&item_ID=88136&group_ID=1367 on May 4, 2010, 2 pages.
Snap-On Incorporated, EEDM596DK, Multimeter, Digital, Advanced, Manual Ranging, downloaded from the World Wide Web at http://buy1.snapon.com/catalog/item.asp?store=snapon-store&item_ID=84657&group_ID=1367 on May 4, 2010, 2 pages.
Snap-On Incorporated, EEDM503D, Multimeter, Digital, Automotive, True RMS, downloaded from the World Wide Web at http://buy1.snapon.com/catalog/item.asp?store=snapon-store&item_ID=84656&group_ID=1367 on May 4, 2010, 1 page.
Fluke, 163/164 MultiFunction Counter Users Manual, Feb. 1, 1997, 102 pages.
Fluke, Fluke 164 2.7 GHz Multifunction Counter Technical Data, May 10, 2007, 11 pages.
Report Lab, OBD-II PIDS, Jul. 6, 2010, 13 pages.
Flores, J., Wireless Diagnostics and Consultancy Services, Vital Engineering, Jan. 4, 2007, 8 pages.
Fluke, Fluke 199B/003 Scopemeter 200 MHz, Dual Portable Multimeter and Oscilloscope, downloaded from the World Wide Web at http://web.archive.org/web/20100413065253/http://www.fluke199.com/ as archived on Apr. 12, 2010, 7 pages.
Fluke Corporation, ScopeMeter 120 and 190 Series incl. 225C and 215C, Technical Data, Jan. 2010, 10 pages.
Fluke Corporation, Fluke 19xC-2x5C Scopemeter, Software version 8.00 onwards, Users Manual, Jul. 2008, 159 pages.
U.S. Appl. No. 12/859,051 filed on Aug. 18, 2010, 51 pages.
Jones, Mike, Senior FAE, Micrel Inc., Ethernet Driving Down Automotive Cost of Ownership; Oct. 31, 2008, 31 pages.
Nology Engineering, Inc., Nology, PDA-Dyno and OBD II Scan Tool Operating Manual, 2009, 37 pages.
OBD-2.COM, OBDII Automotive Scan Tool and Virtual Dashboard, downloaded from the World Wide Web at http://www.obd-2.com/ on Jul. 11, 2010, 15 pages.
U.S. Appl. No. 12/859,077 filed on Aug. 18, 2010, 47 pages.
U.S. Appl. No. 12/858,699 filed on Aug. 18, 2010, 62 pages.
U.S. Appl. No. 12/859,082 filed on Aug. 18, 2010, 36 pages.
U.S. Appl. No. 13/189,940 filed on Jul. 25, 2011, 60 pages.
U.S. Appl. No. 13/205,318 filed on Aug. 8, 2011, 31 pages.
U.S. Appl. No. 13/198,974 filed on Aug. 5, 2011 71 pages.
U.S. Appl. No. 12/913,249 filed on Oct. 27, 2010, 91 pages.
U.S. Appl. No. 12/913,184 filed on Oct. 27, 2010, 90 pages.
U.S. Appl. No. 12/859,011 filed on Aug. 18, 2010, 86 pages.
U.S. Appl. No. 13/198,426 filed on Aug. 4, 2011, 55 pages.
U.S. Appl. No. 12/858,725 filed on Aug. 18, 2010, 46 pages.
U.S. Appl. No. 13/198,530 filed on Aug. 4, 2011, 57 pages.

* cited by examiner

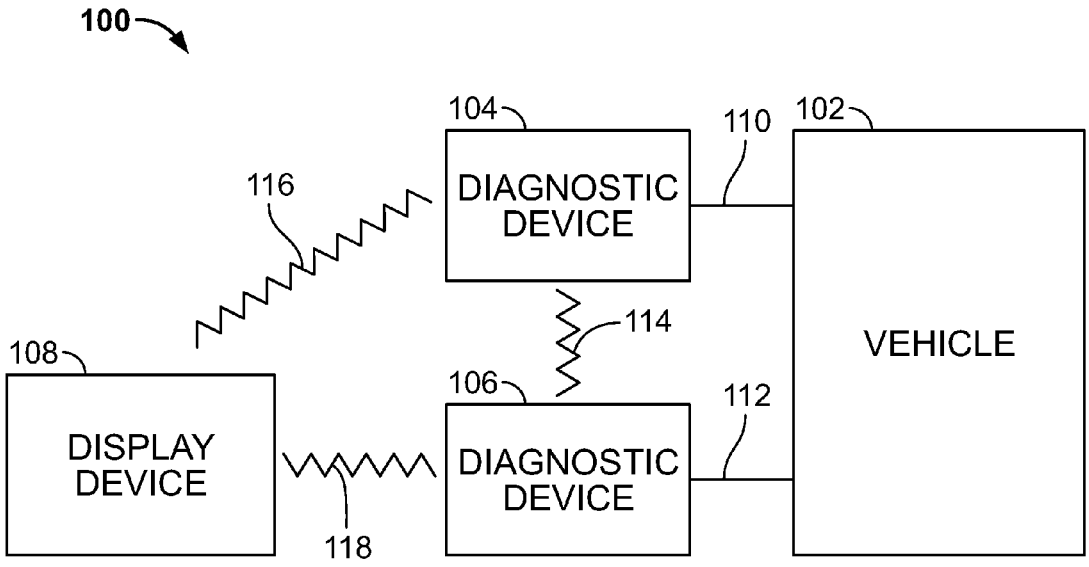

100
104
DIAGNOSTIC DEVICE
110
102
VEHICLE
116
114
108
DISPLAY DEVICE
106
DIAGNOSTIC DEVICE
112
118

FIG. 1

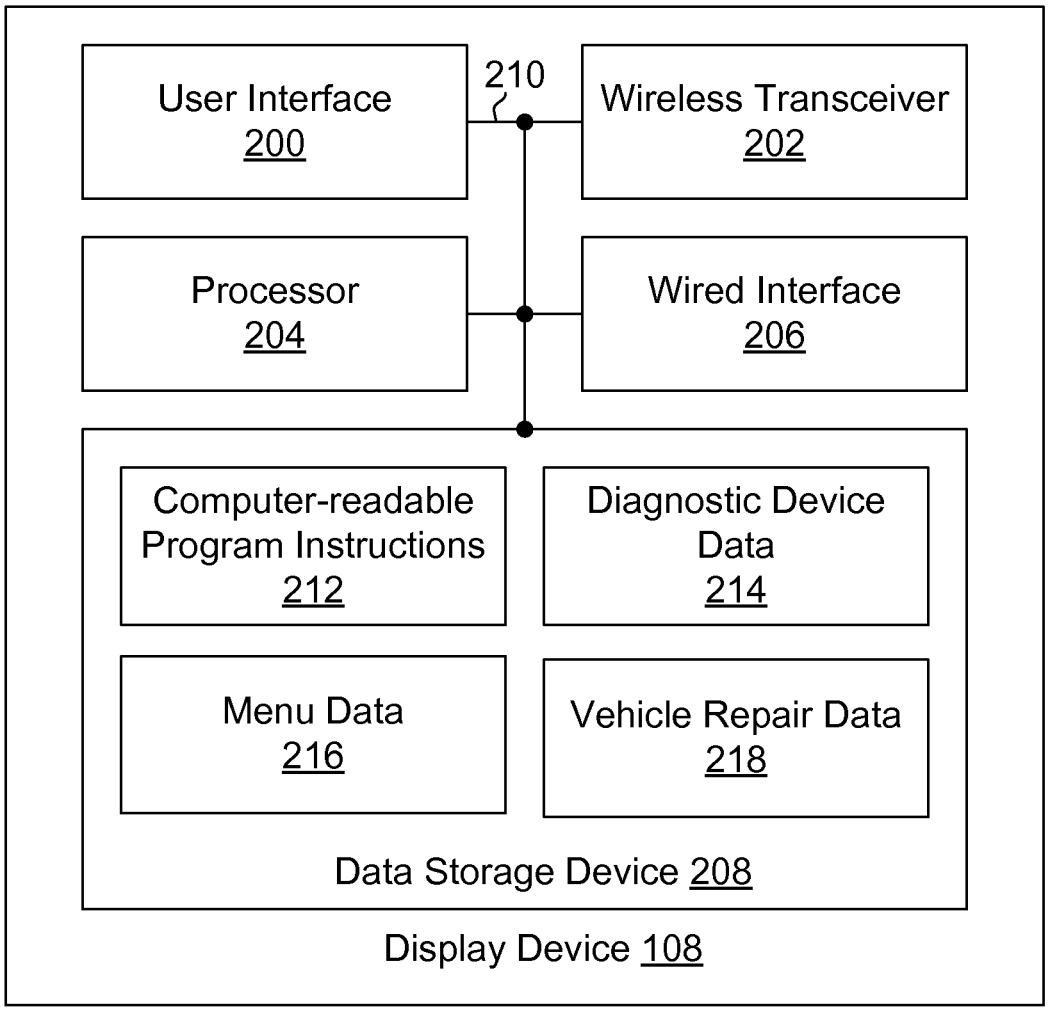

User Interface
200
210
Wireless Transceiver
202
Processor
204
Wired Interface
206
Computer-readable
Program Instructions
212
Diagnostic Device
Data
214
Menu Data
216
Vehicle Repair Data
218
Data Storage Device 208
Display Device 108

FIG. 2

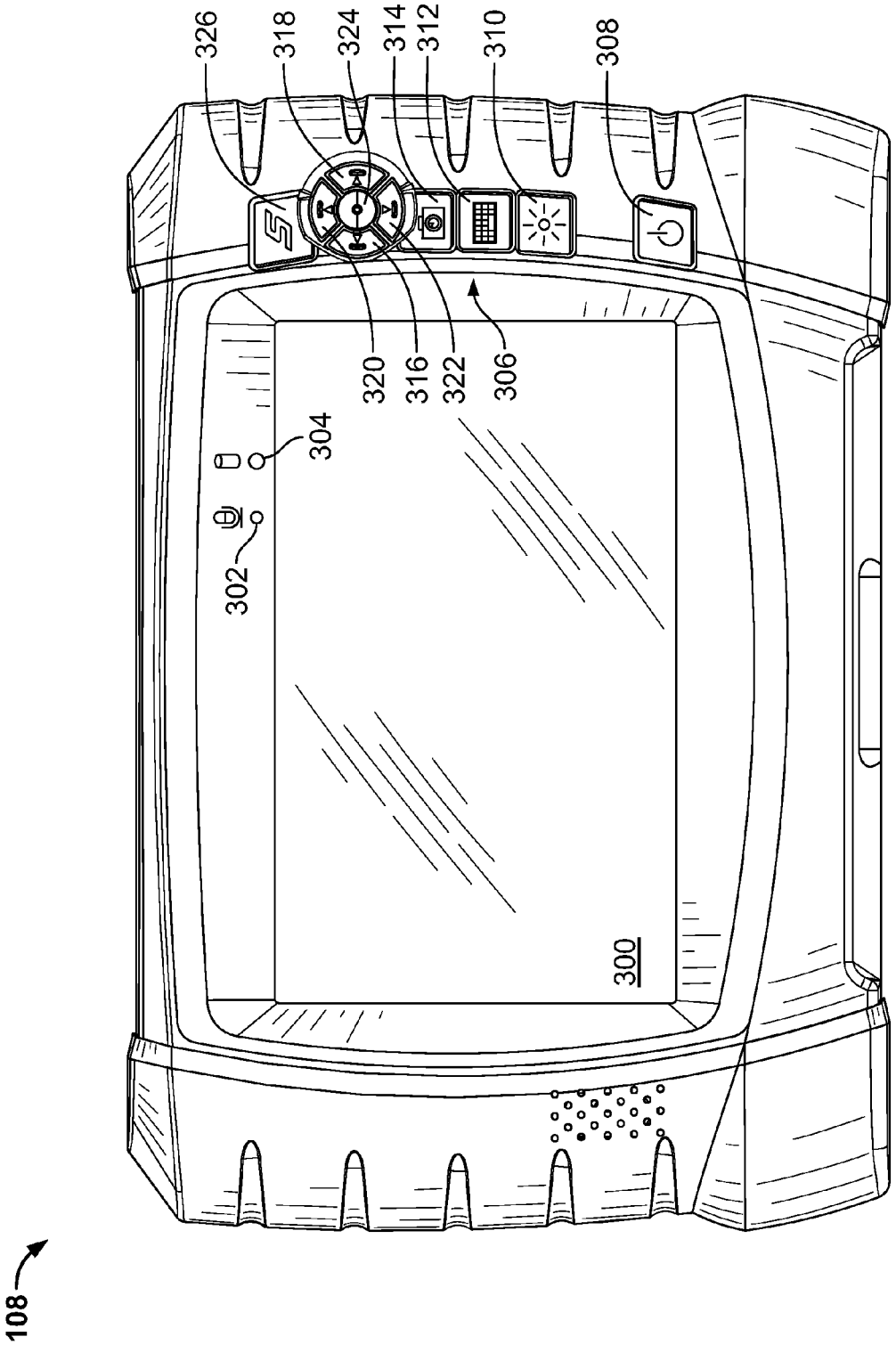


FIG. 3

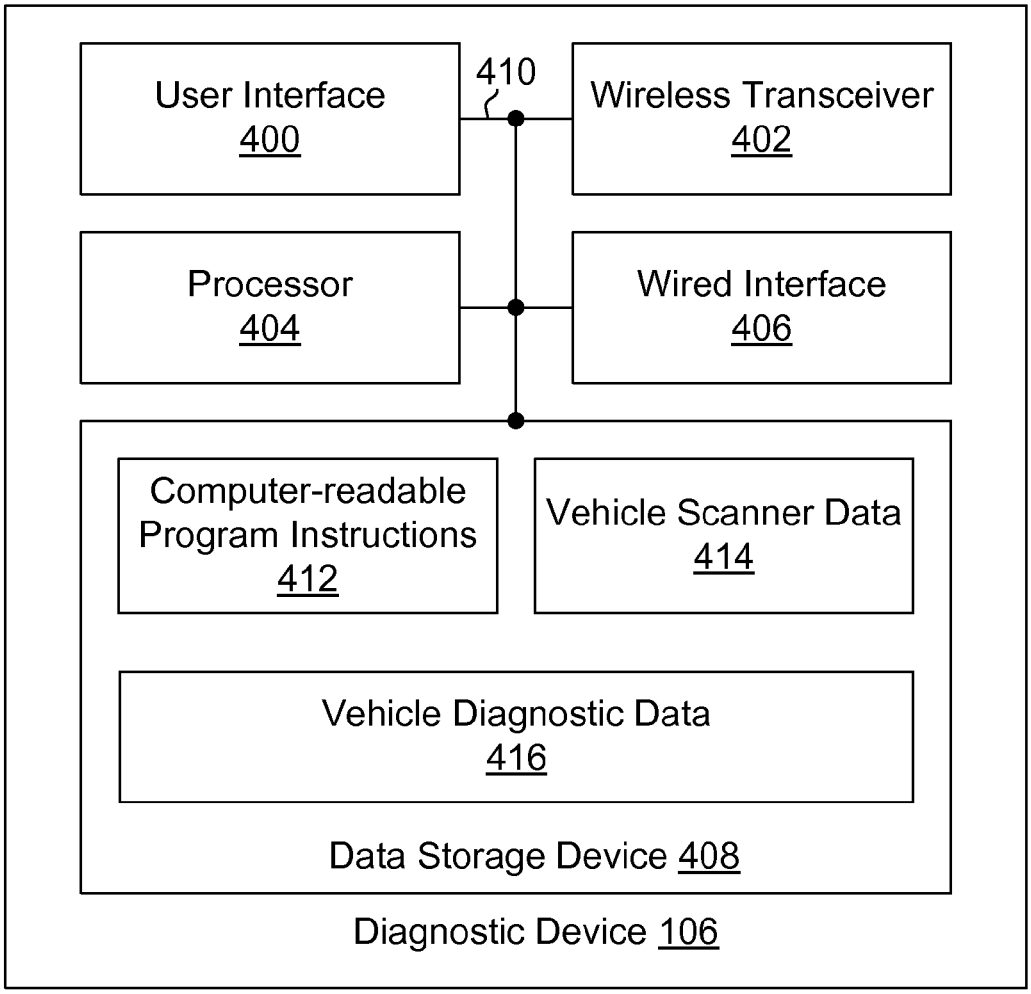

User Interface
400
410
Wireless Transceiver
402
Processor
404
Wired Interface
406
Computer-readable
Program Instructions
412
Vehicle Scanner Data
414
Vehicle Diagnostic Data
416
Data Storage Device 408
Diagnostic Device 106

FIG. 4

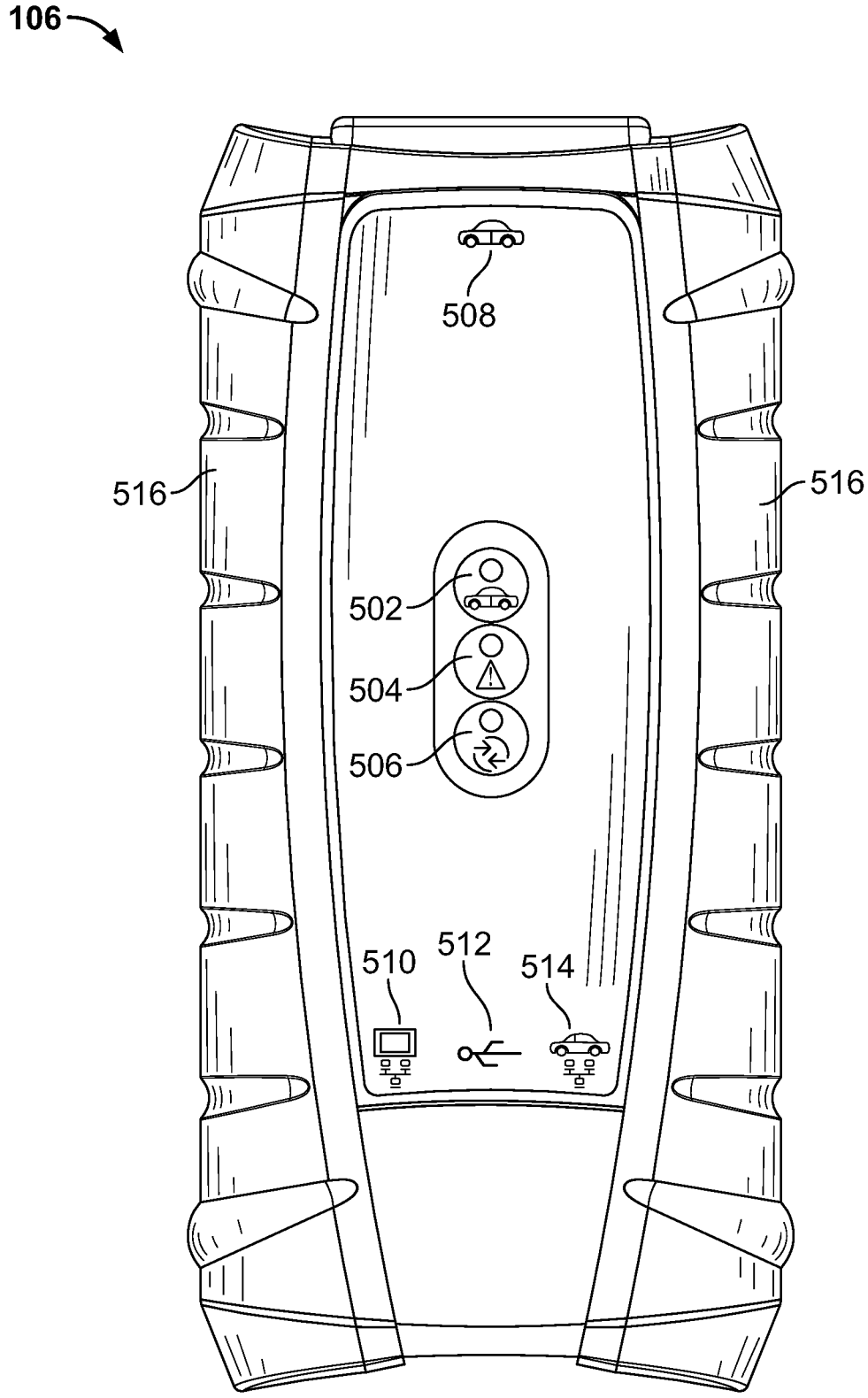


FIG. 5

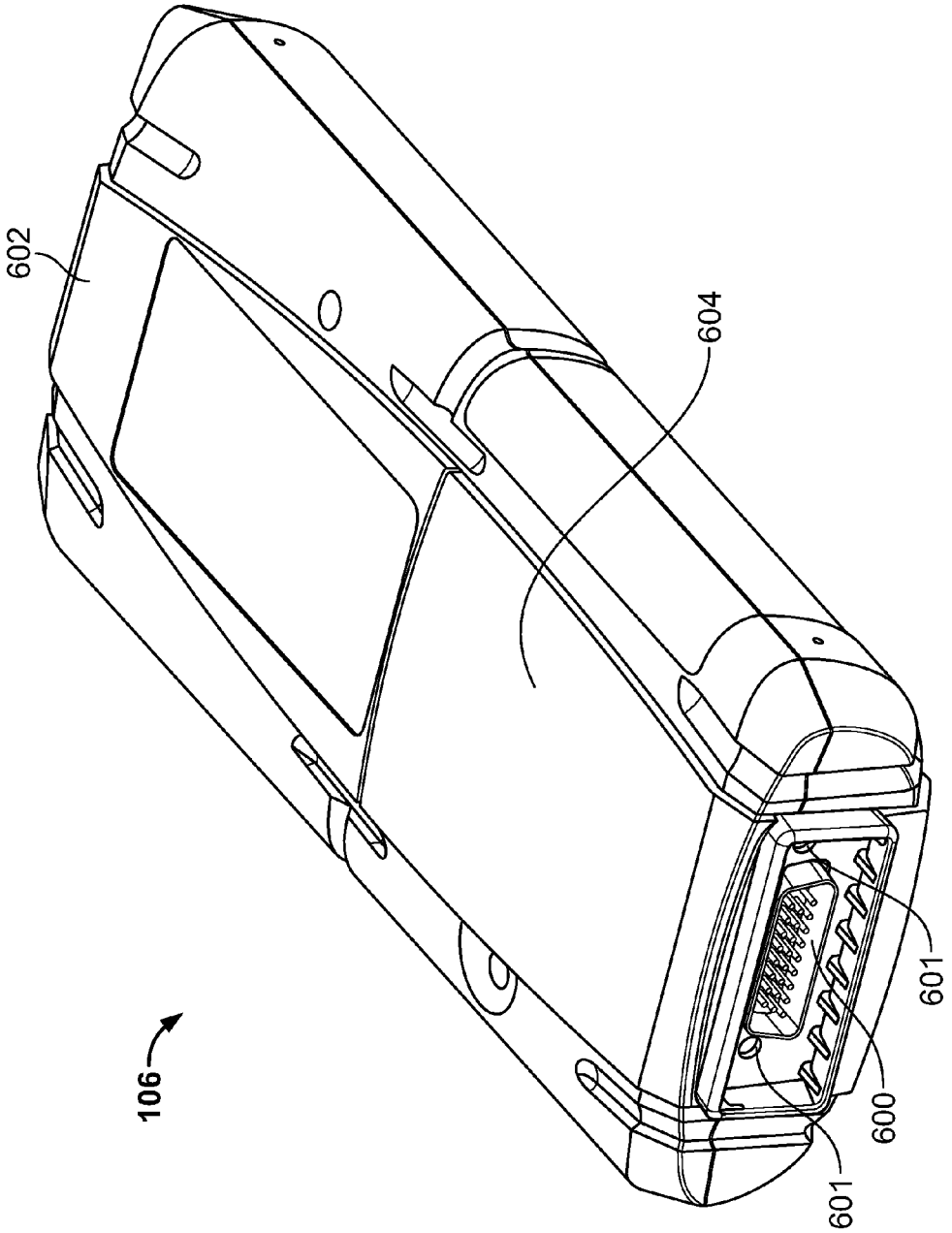


FIG. 6

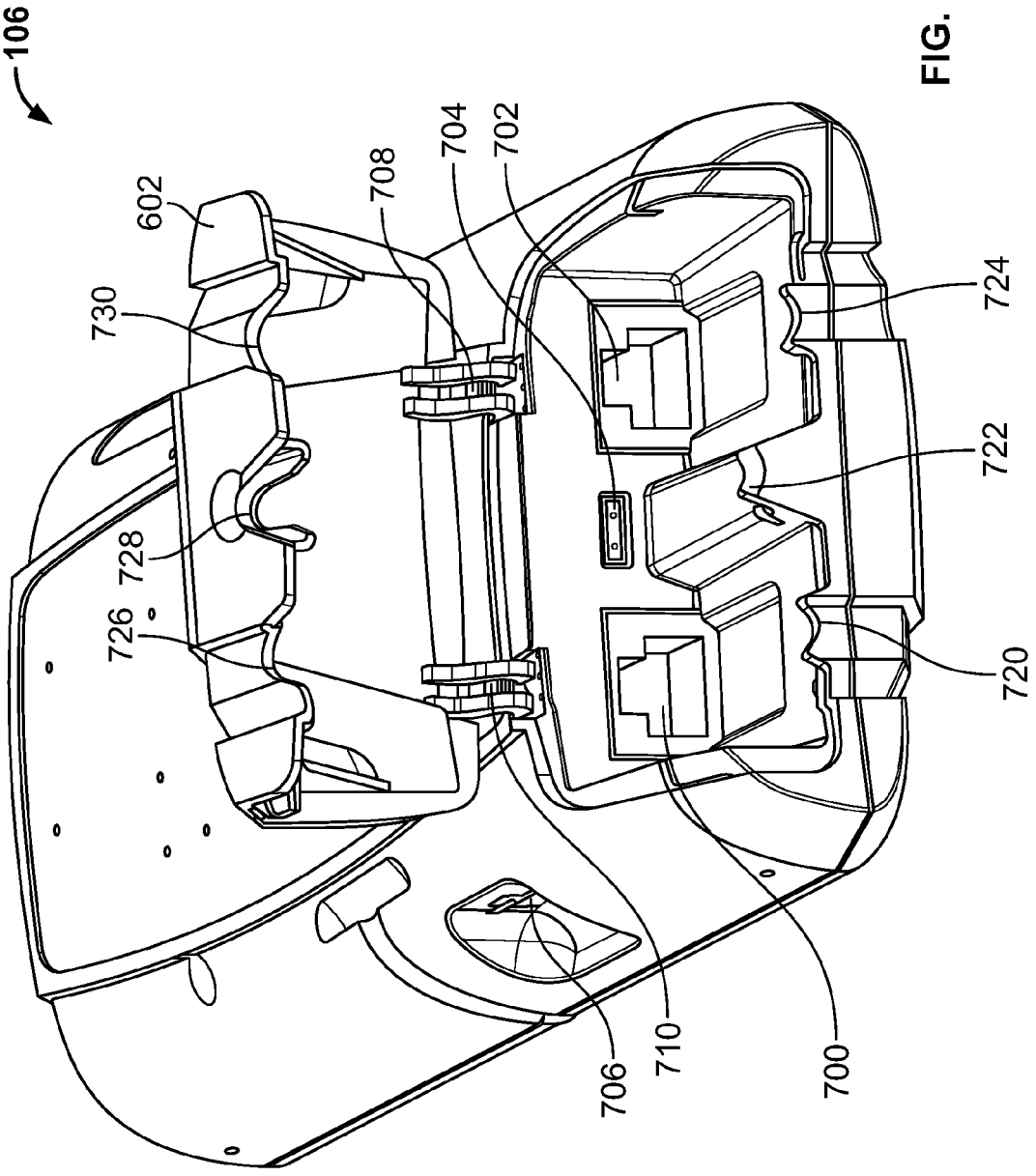


FIG. 7

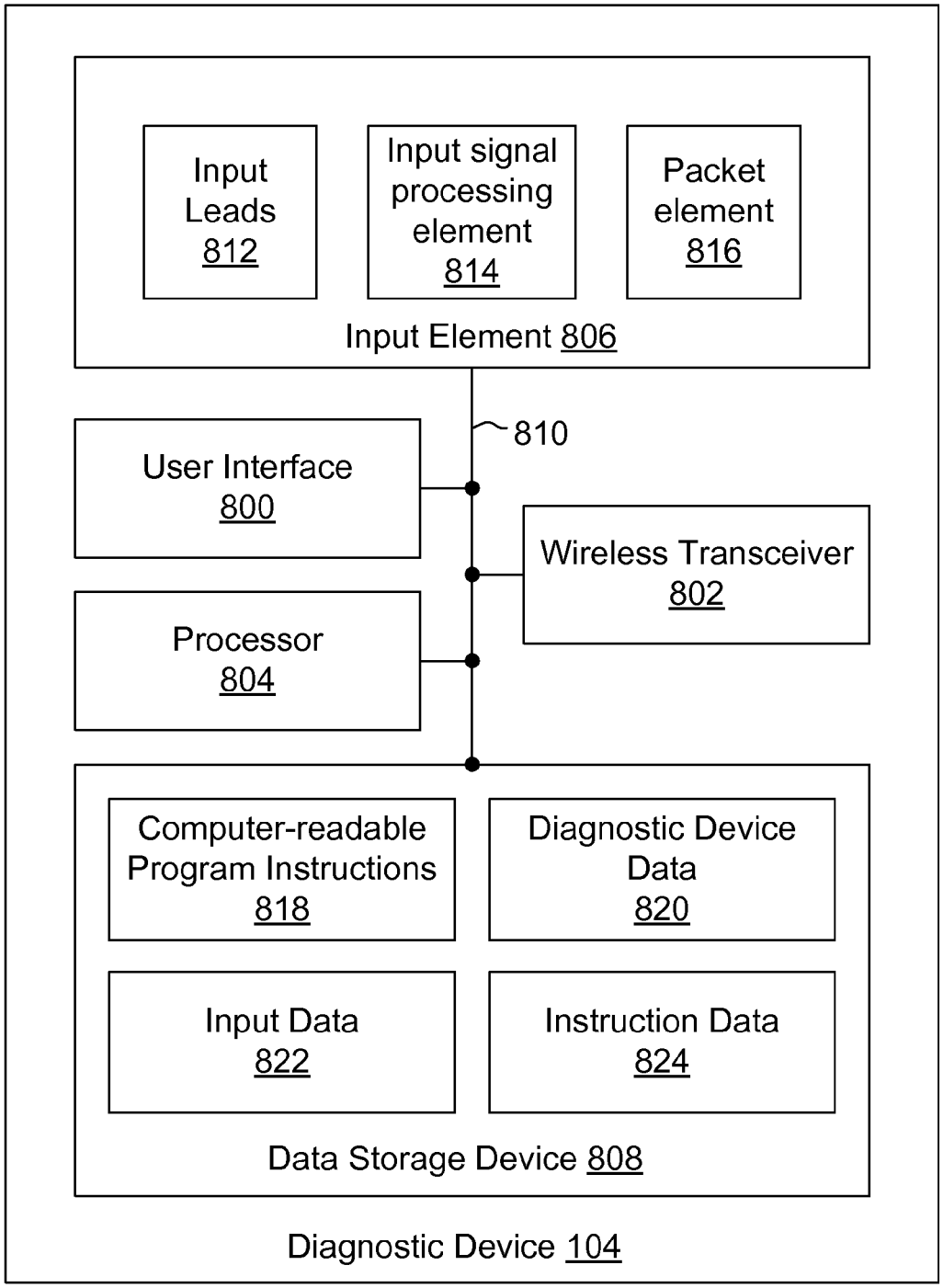

Input Leads 812
Input signal processing element 814
Packet element 816
Input Element 806
810
User Interface 800
Wireless Transceiver 802
Processor 804
Computer-readable Program Instructions 818
Diagnostic Device Data 820
Input Data 822
Instruction Data 824
Data Storage Device 808
Diagnostic Device 104

FIG. 8

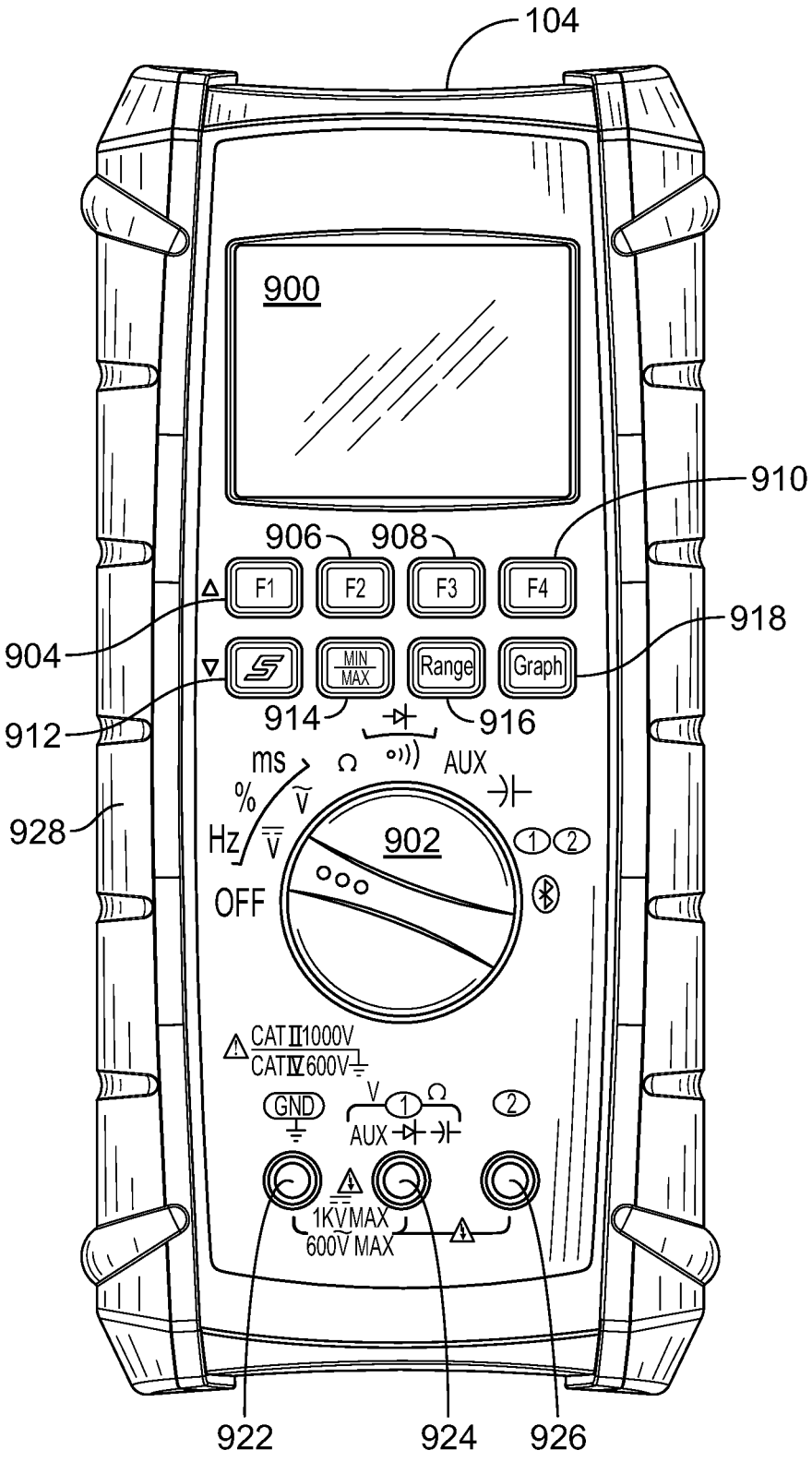

104
900
910
906
908
F1
F2
F3
F4
904
918
MIN MAX
Range
Graph
912
914
916
ms
Ω
AUX
%
Hz
928
902
OFF
CAT II 1000V
CAT IV 600V
GND
V
1
Ω
2
AUX
1KV MAX
600V MAX
922
924
926

FIG. 9

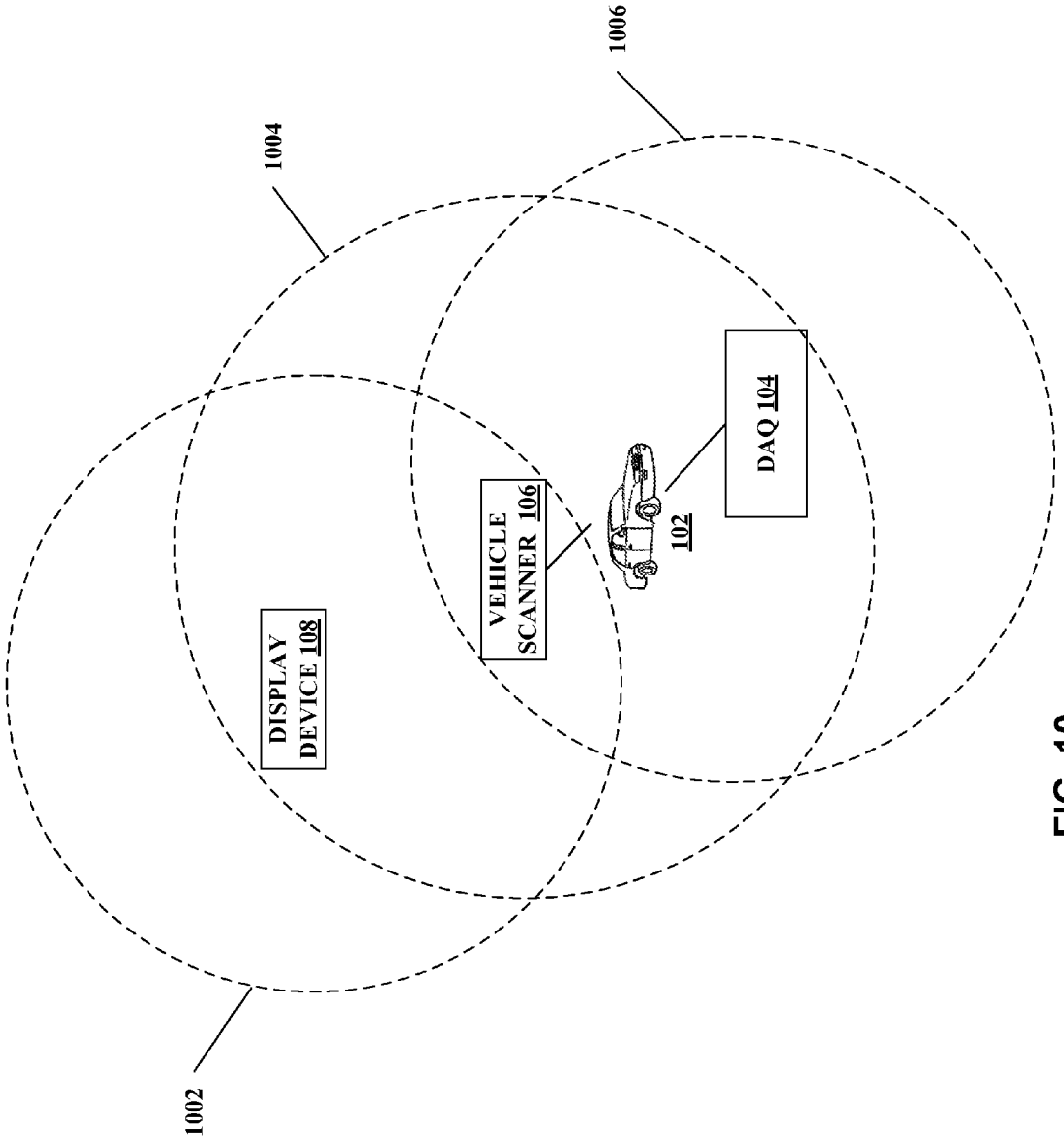

1006
1004
DAQ 104
VEHICLE SCANNER 106
102
DISPLAY DEVICE 108
1002

FIG. 10

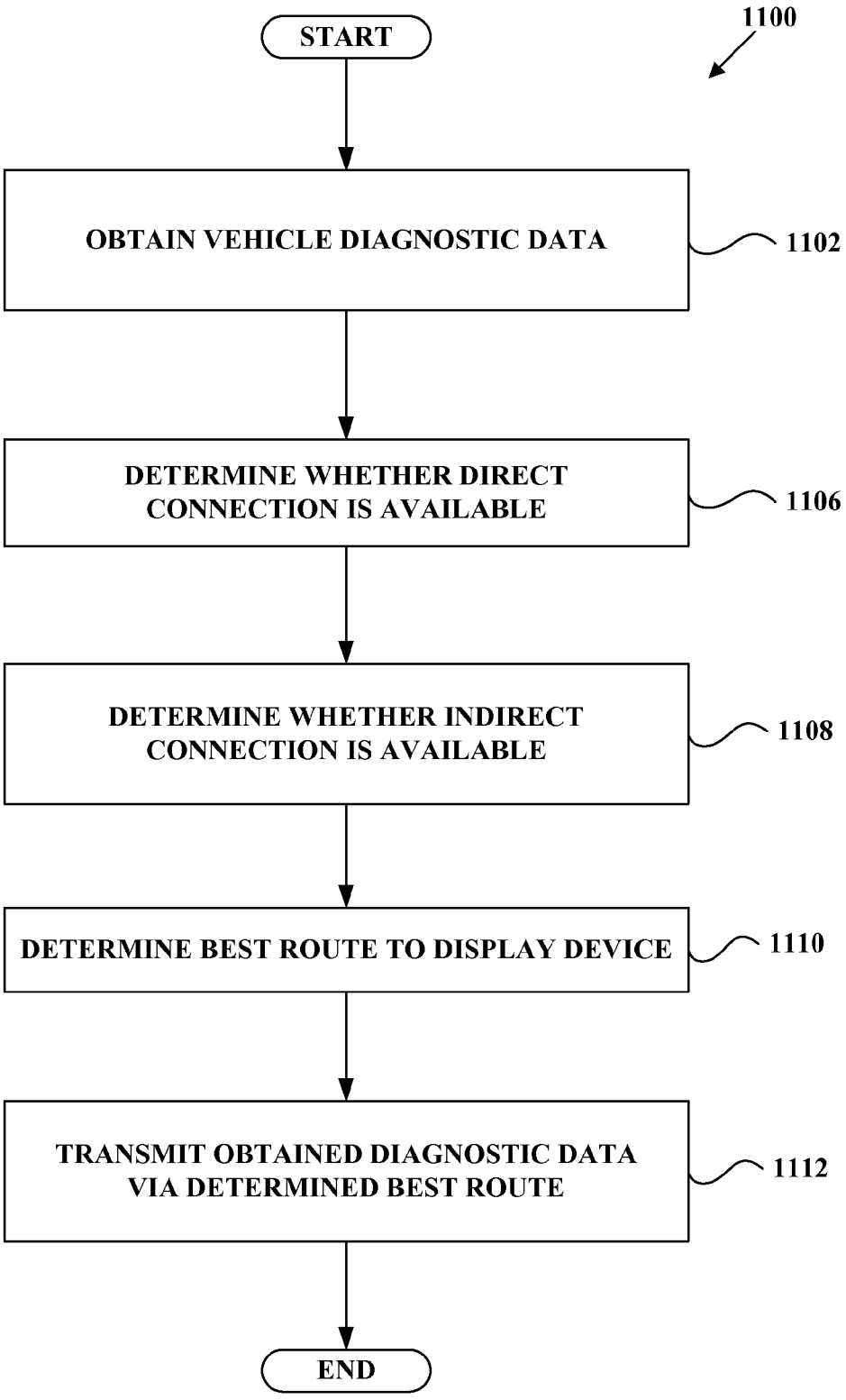

1100
START
OBTAIN VEHICLE DIAGNOSTIC DATA
1102
DETERMINE WHETHER DIRECT CONNECTION IS AVAILABLE
1106
DETERMINE WHETHER INDIRECT CONNECTION IS AVAILABLE
1108
DETERMINE BEST ROUTE TO DISPLAY DEVICE
1110
TRANSMIT OBTAINED DIAGNOSTIC DATA VIA DETERMINED BEST ROUTE
1112
END

FIG. 11

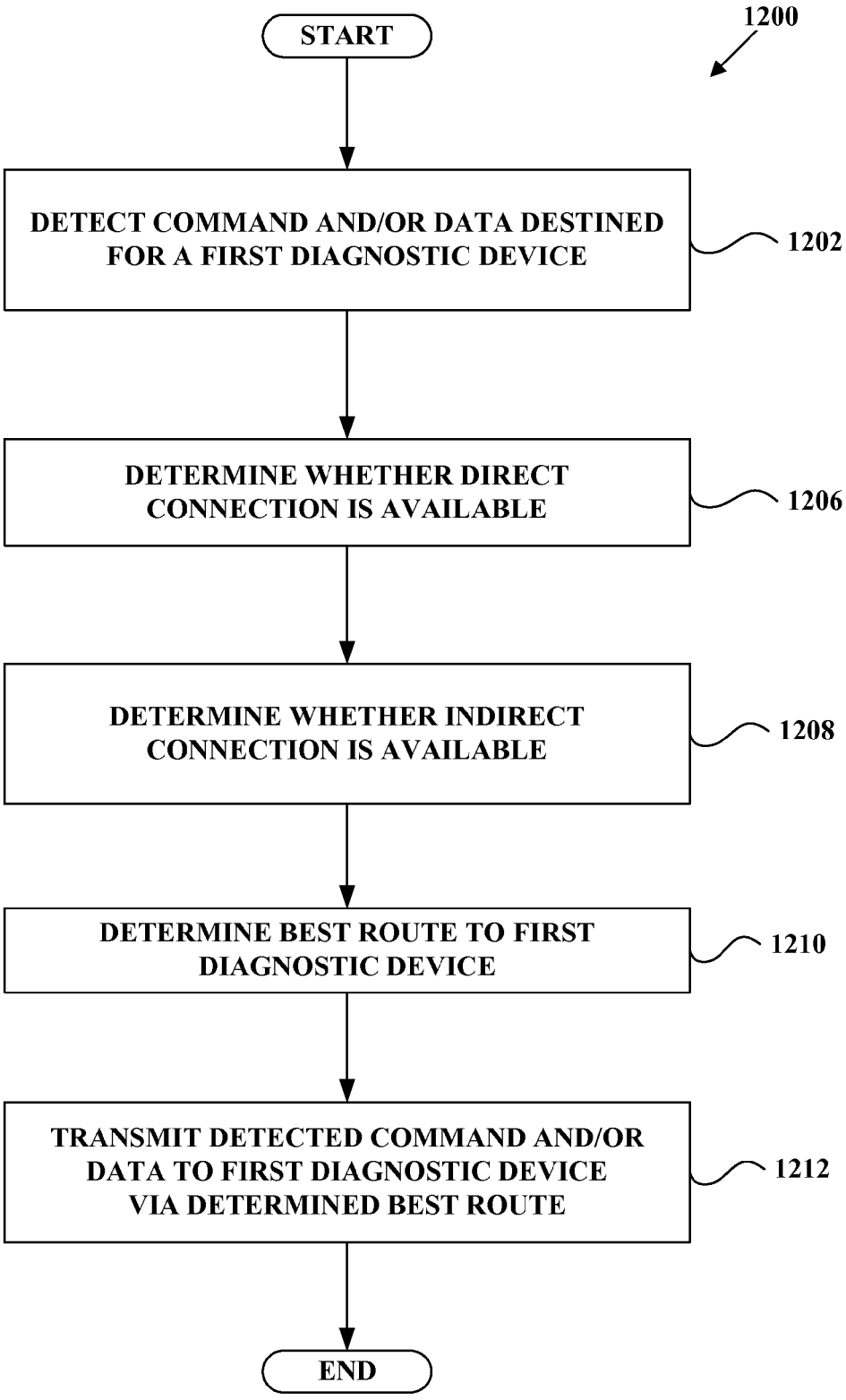

1200
START
DETECT COMMAND AND/OR DATA DESTINED FOR A FIRST DIAGNOSTIC DEVICE
1202
DETERMINE WHETHER DIRECT CONNECTION IS AVAILABLE
1206
DETERMINE WHETHER INDIRECT CONNECTION IS AVAILABLE
1208
DETERMINE BEST ROUTE TO FIRST DIAGNOSTIC DEVICE
1210
TRANSMIT DETECTED COMMAND AND/OR DATA TO FIRST DIAGNOSTIC DEVICE VIA DETERMINED BEST ROUTE
1212
END

FIG. 12

SYSTEM AND METHOD FOR EXTENDING COMMUNICATION RANGE AND REDUCING POWER CONSUMPTION OF VEHICLE DIAGNOSTIC EQUIPMENT

REFERENCE TO RELATED APPLICATION(S)

This application is a continuation of prior U.S. patent application Ser. No. 12/859,040, filed Aug. 18, 2010. U.S. patent application Ser. No. 12/859,040 is incorporated herein by reference.

BACKGROUND

Vehicles, such as automobiles, light-duty trucks, and heavy-duty trucks, play an important role in the lives of many people. To keep vehicles operational, some of those people rely on vehicle technicians to diagnose and repair their vehicle.

Vehicle repair technicians use a variety of tools in order to diagnose and/or repair vehicles. Those tools may include common hand tools, such as wrenches, hammers, pliers, screwdrivers and socket sets, or more vehicle-specific tools, such as cylinder hones, piston ring compressors, and vehicle brake tools.

Modern vehicles have evolved into very complex machines with thousands of various parts that perform a vast array of operations that permit the vehicle to be operated by the user. Additionally, more and more vehicle operations that previously were controlled by mechanical interactions are instead being controlled by electronic control circuits and logic. As with any such complex machine, malfunctions may occur in one or more parts of the vehicle from time to time, including the electronic control circuits.

As a result, repair technicians must now rely on sophisticated electronic equipment to diagnose and repair vehicular malfunctions. Electronic tools such as data acquisition devices (DAQs) and vehicle scanner devices have been developed to interface with a vehicle and diagnose the sophisticated electronic equipment. DAQs incorporate various measurement functions such as voltage and current measurement probes to aid a repair technician in diagnosing a vehicle under test.

Vehicle scanner devices may be used to access electronic equipment within the vehicle under test. Modern vehicles include an on-board diagnostic port (OBD port) or a diagnostic link connector (DLC). An OBD port or DLC generally comprises a plug-in type connector that is coupled to an on-board computer within the vehicle. The on-board computer is then coupled to various sensors at various places within the vehicle. The sensors can report current operating characteristics of vehicle elements and/or sense the existence of a malfunction in the various vehicle elements. By plugging in an appropriate scanner device into the OBD or DLC, status or error codes can be retrieved from the OBD or DLC. These error codes may provide information as to the source of a malfunction in the electronic control circuits in the vehicle.

In order to further process data received from the DLC or OBD port, the vehicle scanner device may transmit the vehicle diagnostic data to another, more robust processing device, such as a display device. The display device may further contain a substantial database of information about the particular vehicle under test from which the data is retrieved, and may correlate the error codes retrieved to particular malfunctions and perhaps display further diagnostic steps that may be taken to diagnose the problem. Further diagnostic steps may include the retrieval of additional diagnostic information from the OBD or DLC port via the vehicle scanner device, or the measurement of vehicle attributes using the DAQ.

By providing the repair technician with detailed information for quickly diagnosing and repairing vehicles, vehicle repair times can be decreased, vehicle turn-over is increased, and as a result, repair technicians may reap increased profits from a same amount of garage space.

OVERVIEW

Disclosed herein are methods and systems that provide for vehicle scanner and DAQ devices that may communicate wirelessly with a more powerful separate display device. By providing for a modular separation of scanner, DAQ, and display devices, and including wireless data connections between them, costs of the individual devices can be reduced while improving ease of use and eliminating garage clutter. In order to compensate for potential interference and loss of wireless connectivity with the display device, and/or to reduce power consumption, embodiments are disclosed that allow commands and/or vehicle data to be relayed from one of the vehicle scanner, DAQ, and/or display device to another of the vehicle scanner, DAQ, and/or display device.

In accordance with a first embodiment of a diagnostic device, a method of obtaining and transmitting vehicle diagnostic data includes the diagnostic device obtaining vehicle diagnostic data via a vehicle interface with a diagnostic port of a vehicle. Once the data is obtained, the diagnostic device determines whether a direct wireless connection with a display device is available. Additionally or alternatively, the diagnostic device determines whether an indirect wireless connection with the display device is available via a second separate vehicle diagnostic device. The diagnostic device may then make a further determination and, responsive to the further determination, indirectly transmit the obtained diagnostic data to the display device via the second separate vehicle diagnostic device.

The further determination may be a determination based on an availability of wireless connections. For example, the further determination may be a determination that a prior-established direct wireless connection with the display device has been interrupted. Alternatively, the further determination may be a determination that the direct wireless connection with the display device is not available and that an indirect wireless connection with the display device via the second separate vehicle diagnostic device is available.

In another embodiment, the further determination may be a determination based on a consideration of power source type and/or power level. For example, the further determination may be a determination that the second separate vehicle diagnostic device is operating off of an external power source, and therefore has a more robust power source. As a result, the diagnostic device may conclude that it can save its own power source (which may be battery-based) by transmitting at a lower power to the second vehicle diagnostic device, and rely upon the second diagnostic device and its more robust power source (which may be, for example, provided by a vehicle under test, a wall socket, or some other source) to relay the diagnostic data to the display device. In the event that both the first and second vehicle diagnostic devices are running on battery power, the further determination may be, for example, a determination that an amount of battery power remaining at the first vehicle diagnostic device is less than an amount of battery power remaining at the second vehicle diagnostic device.

In a further embodiment, determining whether an indirect wireless connection to the display device is available may include the vehicle diagnostic device transmitting a packet to a broadcast address, and responsive to the transmission, wirelessly receiving a packet from the second vehicle diagnostic device indicating an ability to act as a wireless relay agent to the display device.

In one embodiment, the first vehicle diagnostic device is one of a vehicle scanner and a DAQ, and the second separate vehicle diagnostic device is the other of the vehicle scanner and the DAQ. For example, the first vehicle diagnostic device may be a DAQ operating on battery power, and the second vehicle diagnostic device may be a vehicle scanner operating off of an external power source. The external power source may be, for example, a battery provided in a vehicle under test. The diagnostic data may be, for example, diagnostic trouble codes obtained by the vehicle scanner and transmitted to the DAQ for relay to the display device.

In a further embodiment, a method of transmitting diagnostic communications may include a first vehicle diagnostic device receiving a diagnostic communication, consisting of one or more communications selected from the group consisting of vehicle diagnostic information and vehicle diagnostic commands, from one of a second vehicle diagnostic device and a display device via a wireless communications interface using a first wireless protocol. The first wireless protocol may be one of an IEEE 802.11 protocol and a Bluetooth protocol, among other protocols.

Responsive to receiving the diagnostic communication, the first vehicle diagnostic device forwards the diagnostic communication to the other of the second vehicle diagnostic device and the display device via the wireless communications interface using a second wireless protocol. The second wireless protocol may be different from the first wireless protocol. First example, the first wireless protocol may be IEEE 802.11, and the second may be Bluetooth.

Furthermore, the first vehicle diagnostic device may periodically transmit a packet to a broadcast address via its wireless communications interface indicating an ability to act as a relay agent to the display device. Additionally or alternatively, the first vehicle diagnostic device, responsive to receiving a broadcast packet from the second vehicle diagnostic device, may transmit a unicast packet to the second vehicle diagnostic device indicating an ability to act as a relay agent to the display device.

The diagnostic communication may, for example, be a command instructing one of the display device and the second vehicle diagnostic device to execute a function in diagnosing a vehicle malfunction. Alternatively or additionally, the diagnostic communication may be vehicle diagnostic data for use by the one of the display device and the second vehicle diagnostic device in diagnosing a vehicle malfunction. The vehicle diagnostic data may comprise vehicle troubleshooting data retrieved from a vehicle under test, or may comprise image information illustrating how to operate the one of the display device and the second vehicle diagnostic device. Other possibilities exist as well.

These as well as other aspects and advantages will become apparent to those of ordinary skill in the art by reading the following detailed description, with reference where appropriate to the accompanying drawings. Further, it should be understood that the embodiments described in this overview and elsewhere are intended to be examples only and do not necessarily limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Example embodiments of the invention are described herein with reference to the drawings, in which:

FIG. **1** is a block diagram of a system in which a display device and diagnostic devices in accordance with an example embodiment may operate;

FIG. **2** is a block diagram of an example controller/display device;

FIG. **3** illustrates a view of an example controller/display device;

FIG. **4** is a block diagram of a first example diagnostic device (a vehicle scanner);

FIGS. **5-7** illustrate three views of the example vehicle scanner of FIG. **4**;

FIG. **8** is a block diagram of a second example diagnostic device (a data acquisition device (DAQ));

FIG. **9** illustrates a view of the example vehicle DAQ of FIG. **8**;

FIG. **10** illustrates a coverage map in accordance with an example system;

FIG. **11** illustrates a process flow that a diagnostic device may execute in accordance with an embodiment.

FIG. **12** illustrates a process flow that a display device may execute in accordance with an embodiment.

DETAILED DESCRIPTION

I. Example Architecture

FIG. **1** is a block diagram of a system **100** in accordance with an example embodiment. System **100** comprises a vehicle **102** under test, a first diagnostic device **104**, a second diagnostic device **106**, and a controller/display device **108** (display device).

The block diagram of FIG. **1** and other block diagrams and flow charts accompanying this description are provided merely as examples and are not intended to be limiting. Many of the elements illustrated in the figures and/or described herein are functional elements that may be implemented as discrete or distributed components or in conjunction with other components, and in any suitable combination and location. Those skilled in the art will appreciate that other arrangements and elements (for example, machines, interfaces, functions, orders, and groupings of functions, etc.) can be used instead. Furthermore, various functions described as being performed by one or more elements can be carried out by a processor executing computer-readable program instructions from a computer readable medium and/or by any combination of hardware, firmware, and software.

First and second diagnostic devices **104**, **106** may be any device capable of obtaining data from vehicle **102** under test useful in diagnosing a problem with the vehicle **102**. For example, diagnostic devices **104**, **106** may be any one of a data acquisition device (DAQ), a vehicle scanner, an engine analyzer, a gas/exhaust analyzer, a cooling system pressure tester, a thermometer, a battery analyzer, and a cylinder compression tester. Other diagnostic device could also be used. In a preferred embodiment, first diagnostic device **104** is a data acquisition device (DAQ) and second diagnostic device **106** is a vehicle scanner.

DAQ **104** and vehicle scanner **106** may connect to vehicle **102** under test via wired links **110** and **112**, respectively. The vehicle **102** may comprise an automobile, a motorcycle, a semi-tractor, farm machinery, or some other motorized vehicle. System **100** is operable to carry out a variety of functions, including functions for servicing the vehicle **102**. The example embodiments may be used with any desired system or engine. Those systems or engines may comprise items utilizing fossil fuels, such as gasoline, natural gas, propane, and the like, electricity, such as that generated by

battery, magneto, fuel cell, solar cell and the like, wind and/or hybrids or combinations thereof. Those systems or engines may be incorporated into other systems, such as an automobile, a truck, a boat or ship, a motorcycle, a generator, an airplane and the like. DAQ **104** and vehicle scanner **106** may include batteries that provide operational power, or may receive operating power through their respective wired links **110** and **112** with the vehicle **102** or through some other external link. Furthermore, the embodiments described herein may include or be utilized with any appropriate voltage or current source, such as a battery, an alternator, a fuel cell, and the like, providing any appropriate current and/or voltage, such as about 12 Volts, about 42 Volts, and the like.

Each of the DAQ **104**, vehicle scanner **106**, and display device **108** may create and/or maintain a wireless link with any of the other devices via respective wireless links **114**, **116**, and **118**. The wireless links **114**, **116**, and **118** may operate via a same wireless protocol, or via different wireless protocols, the only limitation being that each pair of wirelessly communicating devices in FIG. **1** must both support a same particular wireless protocol to communicate.

Each of the one or more wireless links **114**, **116**, and **118** may be arranged to carry out communications according to an industry standard, such as an Institute of Electrical and Electronics Engineers (IEEE) 802 standard. The IEEE 802 standard may comprise an IEEE 802.11 standard for Wireless Local Area Networks (e.g., IEEE 802.11a, b, g, or n), an IEEE 802.15 standard for Wireless Personal Area Networks, an IEEE 802.15.1 standard for Wireless Personal Area Networks—Task Group 1, an IEEE 802.16 standard for Broadband Wireless Metropolitan Area Networks, or some other IEEE 802 standard. For purposes of this description, a wireless network arranged according to the IEEE 802.11 standard can be referred to as a Wi-Fi network, and a wireless network arranged according to the IEEE 802.15.1 can be referred to as a Bluetooth (BT) network. Other protocols could also or alternatively be used.

Each of the devices **104**, **106**, and **108** may transmit data and/or commands to one another via the wireless links **114**, **116**, and **118**. As an example, display device **108** may establish a wireless link **116** with DAQ **104** and send an instruction to the DAQ **104** to switch to "voltmeter mode." DAQ **104** may then respond by taking a voltage reading from the vehicle **102** and transmitting the voltage reading to display device **108** via the wireless link **116**. Each of the devices **104**, **106**, and **108** may also function to relay data from one device to the other. For example, if the wireless link **118** in FIG. **1** is currently unavailable, or for some other reason, vehicle scanner **106** may transmit diagnostic data to display device **108** via DAQ **104** and wireless links **114** and **116**. Each of wireless links **114** and **116** may operate according to a same wireless protocol (e.g., Bluetooth) or according to different protocols (e.g., Bluetooth and IEEE 802.11, among others). A single transceiver in DAQ **104** may operate in accordance with both protocols, perhaps in a time-shared manner, or two transceivers in DAQ **104** may operate in accordance with each different protocol. In addition to diagnostic data, commands may be transmitted back and forth across wireless links **114** and **116**. For example, display device **108** may transmit commands and/or data to DAQ **104** for relaying to vehicle scanner **106** via wireless links **114** and **116**. A command transferred to vehicle scanner **106** via DAQ **104** may include, for example, a command to retrieve certain error codes from the vehicle **102**.

Each of the devices **104**, **106**, and **108** will now be described in more detail. As set forth above, although in a preferred embodiment devices **104**, **106**, and **108** comprise a DAQ, vehicle scanner, and display device, respectively, other embodiments may comprise different devices performing different functions.

FIG. **2** is a block diagram of display device **108**, which includes a user interface **200**, a wireless transceiver **202**, a processor **204**, a wired interface element **206**, and a data storage device **208**, all of which may be linked together via a system bus, network, or other connection mechanism **210**.

User interface **200** is operable to present data to a user and to enter user selections. User interface **200** may include a display **300** (illustrated in FIG. **3**) that is operable to visually present input data transmitted to wireless transceiver **206** from vehicle scanner **106** or DAQ **104**. Display **300** may also simultaneously display input data received from multiple diagnostic devices, such as input data received from both DAQ **104** and vehicle scanner **106**. Display **300** may also display data stored at data storage device **208**, such as menu data **216** or vehicle repair data **218**. User interface **200** may further include an input selection element that is operable to enter a user selection. Further examples of input selection elements are further illustrated in FIG. **3**.

Wireless transceiver **202** comprises a wireless receiver and transmitter operable to carry out wireless communications with one or more of DAQ **104**, vehicle scanner **106**, and/or some other diagnostic device that is operating within wireless communication range of display device **108**. As an example, wireless transceiver **202** may comprise a transceiver that is operable to carry out communications via a BT network. For purposes of this description, a transceiver that is operable to carry out communications via a BT network can be referred to as a BT transceiver. As another example, wireless transceiver **202** may comprise a transceiver that is operable to carry out communications via a Wi-Fi network. For purposes of this description, a transceiver that is operable to carry out communications via a Wi-Fi network can be referred to as a Wi-Fi transceiver. Other wireless communications protocols could also or alternatively be used, including, for example, WiMAX, Cellular, ZigBee, and Wireless USB, among others.

In accordance with an embodiment in which devices **104**, **106**, and **108** each include a single wireless transceiver (e.g., a BT transceiver), one of the devices, such as display device **108**, may operate as a master device, and the other devices, such as DAQ **104** and vehicle scanner **106**, may operate as slaves to the master. Other arrangements are possible as well. Vehicle scanner **106** and display device **108** may transmit communications via a wireless link **118** using, for example, a time-division duplex arrangement and synchronized to a clock signal of the master.

Wireless transceiver **202** is not limited to a single wireless transceiver. For example, wireless transceiver **202** may comprise a BT transceiver and a Wi-Fi transceiver. In accordance with such an example, the BT transceiver may communicate with DAQ **104** and/or vehicle scanner **106** via a BT network, and the Wi-Fi transceiver may communicate with DAQ **104** and/or vehicle scanner **106** via a Wi-Fi network.

In accordance with an embodiment in which display device **108** includes two transceivers (e.g., a BT transceiver and a Wi-Fi transceiver) and DAQ **104** and/or vehicle scanner **106** each include two transceivers (e.g., a BT transceiver and a Wi-Fi transceiver), DAQ **104** and/or vehicle scanner **106** may simultaneously transmit data to display device **108** for display via either one or both of the BT and Wi-Fi networks.

Each wireless transceiver of the example embodiments may operate in a transceiver-on-state. In the transceiver-on-state, the transceiver is powered on. While operating in the transceiver-on-state, the transceiver can transmit and receive data via an air interface. For some transceivers, while oper-

ating in the transceiver-on-state, the transceiver can transmit and receive data via the air interface simultaneously. For other transceivers, while operating in the transceiver-on-state, the transceiver can either transmit or receive data via the air interface at any given time. Each wireless transceiver of the example embodiments may also operate in a transceiver-off-state or low-power-state. While operating in the transceiver-off-state or low-power-state, the transceiver is powered off or in a low-power state and the transceiver refrains from transmitting and/or receiving data.

Each wireless transceiver of the example embodiments may also operate to relay communications from one device to another. In the case of having a single transceiver, data received from one device may be buffered internally prior to transmitting the data to another different device. In the case of having two or more transceivers, data received from one device on a first transceiver may be routed to the second transceiver for transmission to the another different device concurrently with reception of additional data at the first transceiver.

Wired interface **206** may include one or more wire-line ports. Each port provides an interface to display device **108** and to one or more circuits. In one respect, the one or more circuits may comprise electrical circuits, such as the electrical circuits of a Universal Serial Bus (USB) cable or the electrical circuits of an Ethernet cable (e.g., a CAT 5 cable). In another respect, the one or more circuits may comprise optical fibers that are operable to carry optical signals. Other examples of the one or more circuits are also possible.

Processor **204** may comprise one or more general purpose processors (e.g., INTEL microprocessors) and/or one or more special purpose processors (e.g., digital signal processors). Processor **204** may be configured to execute computer-readable program instructions (CRPI) **212** that are contained in computer-readable data storage device **208** and which cause the processor **204** to perform the functionality described herein.

Data storage device **208** may comprise a computer-readable storage medium readable by processor **204**. In the context of this document, a computer-readable medium is an electronic, magnetic, optical, or other physical device or means that can contain or store a computer program for use by, or in connection with, a computer related system or method. The methods can be embodied in any computer-readable medium for use by or in connection with an instruction execution system, apparatus, or device, such as a computer-based system, processor-containing system, or other system that can fetch the instructions from the instruction execution system, apparatus, or device and execute the instructions. Data storage device **208** may contain various data including, but not limited to, CRPI **212**, diagnostic device data **214**, menu data **216**, and/or vehicle repair data **218**. For brevity in this description, computer-readable program instructions are sometimes referred to as program instructions.

Diagnostic device data **214** may include data associated with a device that is arranged to communicate with display device **108** via one or more wireless communication links. For example, diagnostic device data **214** may include data associated with one of the DAQ **104** and vehicle scanner **106**, such as a radio identifier, MAC address, security key, and/or password information. The associated data may be received at display device **108**, for storing as diagnostic device data **214**, during a pairing process carried out between display device **108** and the DAQ **104** and/or vehicle scanner **106**. For example, the pairing process between vehicle scanner **106** and display device **108** may include vehicle scanner **106** providing display device **108** with data associated with vehicle scanner **106** and display device **108** providing vehicle scanner **106** with data associated with display device **108**. After carrying out the pairing process, display device **108** may use the stored diagnostic device data **214** in establishing the communication link **118** with vehicle scanner **106**. Diagnostic device data **214** is not limited to data associated with one diagnostic device. In that regard, diagnostic device data **214** may also include data associated with DAQ **104** and other devices not illustrated in the figures.

Menu data **216** comprises data that can be visually presented via user interface **200**. Menu data **216** may include, for example, icons and images that provide a user with a graphical representation of input and functionality options. User controls **306** (See FIG. **3**) may then be used to traverse the menu data **216** displayed on the display **300**.

CRPI **212** may comprise program instructions that are executable by processor **204** to perform functions represented by the program instructions, such as operating system program instructions that provide for direct control and management of hardware components such as processor **204**, data storage device **208**, and user interface **200**. The operating system can manage execution of other program instructions within CRPI **212**. As an example, the operating system may comprise the Windows XP Embedded (XPe) operating system available from Microsoft Corporation, Redmond, Wash., United States. Other examples of operating system are also possible.

CRPI **212** may further comprise program instructions (referred to herein as PI-**212**-A) that are executable by processor **204** so as to cause display device **108** to operate as a peripheral manager (PM) that manages functions carried out by peripheral devices, such as DAQ **104** and vehicle scanner **106**.

CRPI **212** may further comprise program instruction (referred to herein as PI-**212**-B) that are executable by processor **204** to cause the wireless transceiver **202** to transmit instructions or commands (such as mode-selection commands) to one or more of DAQ **104** and vehicle scanner **106**, or to one of DAQ **104** and vehicle scanner **106** for relaying to the other. In one respect, an instruction mode-selection command may be addressed to a specific diagnostic device, such as DAQ **104**. In another respect, the instruction or mode-selection command may be broadcast to any device within a transmission range of the wireless transceiver **202**. In either respect, the instruction or mode-selection command may or may not include data that identifies the display device **108** as the source of the instruction or mode-selection command.

Next, FIG. **3** illustrates a front view of an example embodiment of display device **108** with which vehicle scanner **106** may communicate. Display device **108** includes a display **300**, a status indicator **304** (e.g., a light emitting diode (LED)), and user controls **306**.

Display **300** may comprise a liquid crystal display (LCD), a plasma display, an electrophoretic display, or some other type of display. Display **300** is operable to visually present (e.g., display) data to a user, including, for example, vehicle diagnostic data transmitted to the display device **108** from a diagnostic device **104**, **106**. For purposes of this description, data displayed at display device **108** is referred to as "displayed data." The data received and presented on the display **300** may take the form of an alphanumeric presentation, a graphical presentation, or some other type of presentation.

User controls **306** are operable to enter a user selection. User controls **306** may be arranged in various ways. In that regard, user controls **306** may be arranged to include a keypad, rotary switches, push buttons, or some other means to enter a user selection. As set forth in the example embodiment

illustrated in FIG. **3**, user controls **306** may include, among others, a power button **308**, a brightness button **310**, a keyboard button **312**, a cursor left button **316**, a cursor right button **318**, a cursor up button **320**, a cursor down button **322**, a menu item selection button **324**, and a quick access button **326**. Table 1 lists example user selections that can be entered using user controls **306**. Other examples of user controls **306** and other examples of user selections are also possible.

TABLE 1

User Button	Example User Selection
Power button 308	Turn display device 108 power on and off.
Brightness button 310	Increase or decrease a brightness of display 300.
Keyboard button 312	Display keyboard at display 300.
Cursor left button 316	Move a cursor, displayed at display 300, to the left.
Cursor right button 318	Move a cursor, displayed at display 300, to the right.
Cursor up button 320	Move a cursor, displayed at display 300, upwards.
Cursor down button 322	Move a cursor, displayed at display 300, downwards.
Menu item selection button 324	Select a menu item from a displayed menu data.
Quick access button 326	Select a function that pertains to a current operating mode of display device 108.

Next, FIG. **4** is a block diagram of a diagnostic device **106**, and FIGS. **5** and **6** illustrate two different views of the diagnostic device **106**. As illustrated in FIG. **4**, diagnostic device **106** includes a user interface **400**, a wireless transceiver **402**, a processor **404**, a wired interface **406**, and a data storage device **408**, all of which may be linked together via a system bus, network, or other connection mechanism **410**. User interface **400** is operable to present information to a user of diagnostic device **106**. Elements of user interface **400** are illustrated in FIG. **5**. As set forth earlier, in a preferred embodiment, diagnostic device **106** may be a vehicle scanner device for retrieving status and error codes from vehicle **102** under test.

Wireless transceiver **402** comprises a wireless receiver and transmitter operable to carry out wireless communications with one or more of DAQ **104**, display device **108**, and/or some other device that is operating within wireless communication range of vehicle scanner **106**. As an example, wireless transceiver **402** may comprise a transceiver that is operable to carry out communications via a BT network. As another example, wireless transceiver **402** may comprise a transceiver that is operable to carry out communications via a Wi-Fi network.

Wireless transceiver **402** is not limited to a single wireless transceiver. For example, wireless transceiver **402** may comprise both a BT transceiver and a Wi-Fi transceiver. In accordance with such an example, the BT transceiver may communicate with display device **108** and/or DAQ **104** via a BT network, and the Wi-Fi transceiver may communicate with display device **108** and/or DAQ **104** via a Wi-Fi network.

Wireless transceiver **402** may also operate to relay communications from one device to another. In the case of having a single transceiver, data received from one device may be buffered internally prior to transmitting the data to another different device. In the case of having two or more transceivers, data received from one device on a first transceiver may be routed to the second transceiver for transmission to the another different device concurrently with reception of additional data on the first transceiver. In one embodiment, wireless transceiver may operate to relay vehicle diagnostic data obtained by diagnostic device **104** to display device **108** via wireless links **114** and **118**, and/or may operate to relay instructions or commands (such as mode selection commands) from display device **108** to diagnostic device **104** via wireless links **114** and **118**.

Wired interface **406** may comprise one or more wire-line ports. As an example, wired interface **406** may include wired ports **600** (illustrated in FIG. **6**), wired ports **700**, **702**, and **704**, and slot **706** (all illustrated in FIG. **7**), some of which may be located under port cover **602**.

Port **600** may be a vehicle interface port that communicatively connects the vehicle scanner **106** to the vehicle **102** via wired link **112**. In that regard, wired link **112** may comprise a vehicle interface cable having two cable ends. A first cable end of the vehicle interface cable may include a connector that is connectable to and removable from port **600**. A second cable end of the vehicle interface cable may include a connector that is connectable to and removable from a connector in the vehicle **102**. The connector interface in the vehicle **102** may be arranged according to a particular connector standard, such as Society of Automotive Engineers (SAE) specification J-1962 or some other connector standard.

Ports **700** and **702** may comprise respective Ethernet ports. Each Ethernet port may communicatively connect to a first end of a respective Ethernet cable. A second end of a respective Ethernet cable may connect to an Ethernet port directly or indirectly connected to a local or wide area network (such as the Internet). Another respective Ethernet cable may connect the vehicle scanner **106** to the display device **108** via a corresponding Ethernet port provided on the display device **108**. Ethernet ports **700** and **702** may additionally provide a path for upgrading internal program code within the vehicle scanner **106**, such as CRPI **412**.

Port **704** may comprise a USB port. The USB port **704** may communicatively connect to a first end of a USB cable (not shown). A second end of the USB cable may connect to a corresponding USB port provided on the display device **108**. Alternatively, USB port **704** may connect the vehicle scanner **106** to a personal digital assistant (PDA) device. In this mode, the PDA may act as a USB master and provide instructions to and receive data from, the vehicle scanner **106**. Further, in the event that a mass storage device (such as a flash memory stick) is plugged into the USB port **704**, USB port **704** may provide data storage in addition to or in place of data storage device **408**.

Slot **706** may be a memory card slot that allows additional storage capacity to be added to the vehicle scanner device **106** by insertion of a corresponding memory card, and/or allows propriety diagnostic programs to be loaded via memory card.

Wired interface **406** may further include a configurable set of switches and circuits in communication with port **600** in order to configure port **600** to properly communicate with a particular vehicle **102** under test. More specifically, because different makes and models of vehicles **102** utilize different signaling standards on their respective diagnostic port, wired interface **406** may include circuits and switches that allow the single port **600** to interface with a varying set of vehicle diagnostic port standards. For example, under the OBD II standard umbrella, signaling interfaces compliant with SAE J1850 PWM, SAE J1850 VPW, ISO 9141-2, ISO 14230 KWP2000, and ISO 15765 CAN could all potentially be used on vehicle **102**. Switch information may be stored locally in data storage device **408** and, in response to receiving vehicle information from display device **108**, processor **404** may retrieve and use the information to set switches and circuits to match the required signaling standard. Alternatively or addi-

tionally, vehicle scanner **106** may receive circuit and switch instructions via wireless transceiver **402** and/or wired interface **406** from display device **108** or from some other device.

Processor **404** may comprise one or more general purpose processors (e.g., INTEL microprocessors) and/or one or more special purpose processors (e.g., digital signal processors). Processor **404** may be configured to execute CRPI **412** that are contained in computer-readable data storage device **408** and which cause the processor **404** to perform the functionality described below.

Data storage device **408** may comprise a computer-readable storage medium readable by processor **404**. Data storage device **408** may contain various data including, but not limited to, CRPI **412**, vehicle scanner data **414**, and vehicle diagnostic data **416**. CRPI **412** may comprise program instructions for carrying out any one or more of the vehicle scanner **106** functions herein described. Vehicle scanner data **414** may include switch settings for configuring wired interface **406** or commands/data received from display device **108**, for configuring wired interface **406** and communicating with the vehicle **102**.

Vehicle scanner data **414** may further include data associated with a device that is arranged to communicate with vehicle scanner **106** via one or more wireless communication links. For example, vehicle scanner data **414** may include data associated with one of the DAQ **104** and display device **108**, such as a radio identifier, MAC address, security key, and/or password information. The associated data may be received at vehicle scanner **106**, for storing as vehicle scanner data **414**, during a pairing process carried out between display device **108** and the vehicle scanner **106**, or between the DAQ **104** and the vehicle scanner **106**. For example, the pairing process between vehicle scanner **106** and display device **108** may include vehicle scanner **106** providing display device **108** with the data associated with vehicle scanner **106** and display device **108** providing vehicle scanner **106** with data associated with display device **108**. After carrying out the pairing process, vehicle scanner **106** may use the stored pairing data in establishing the communication link **118** with display device **108**. Vehicle scanner data **414** may also include data associated with DAQ **104** and other devices not illustrated in the figures.

Vehicle diagnostic data **416** may include vehicle diagnostic data received from the vehicle **102**, including for example, sensor data or error code data. Other data retrieved from the vehicle **102** could also be stored in vehicle diagnostic data **416**.

Data storage device **408** may be permanent internal storage comprised of, for example, magnetic or semiconductor-based memory, and/or may be a removable memory device, such as a flash card or USB memory stick, or may comprise a combination of the above. Data storage device **408** may comprise a removable card or stick inserted into one or more of USB port **1308** and/or a memory card inserted into memory card slot **1306**. Other types of storage could also be used.

Next, FIG. **5** illustrates a front view of an example embodiment of vehicle scanner **106**. As set forth in FIG. **5**, the front face of vehicle scanner **106** includes visual indicators **502-514** and side grips **516**. Visual indicators **502**, **504**, and **506**, which may be part of user interface **400**, may comprise respective light emitting diodes (LEDs) or some other visual indictor that is operable to convey information to a user. Data storage device **408** may include CRPI executable by processor **404** to turn visual indicators **502**, **504**, and **506** on and off to reflect a corresponding status of the vehicle scanner **106**.

Visual indicator **502** may turn on to indicate that vehicle scanner **106** is receiving electrical power from vehicle **102**. Because vehicle scanner **106** may not include its own power source, it may rely upon vehicle **102** to provide it with operating power via vehicle interface port **600**. If visual indicator **502** fails to light after connecting vehicle scanner **106** to the vehicle **102**, a repair technician may know to test the vehicle's electrical system. Absent another power source, such as a local battery power source, vehicle scanner **106** may fail to operate. Alternatively, vehicle scanner **106** may be provided with a battery to allow operation without relying on vehicle **102**'s power supply.

Visual indicator **504** may turn on and off in a periodic manner so as to flash (e.g., turn on for 1 second and then turn off for 1 second). In particular, visual indicator **504** may flash in specific sequences so as to identify any of a variety of diagnostic or error codes. The diagnostic codes, for example, could pertain to (i) an error in the vehicle **102**, (ii) an error within the vehicle scanner **106**, (iii) an error communicating with display device **108**, or (iv) or some other error/status. As an example, visual indicator **502** may flash 3 times, wait, and then flash 2 more times, so as to visually present a diagnostic code of 32, which could imply that a wireless connection with display device **108** has failed or that no network path to display device **108** can be found.

Visual indicator **506** may turn on to indicate that vehicle scanner **106** is carrying out communications with vehicle **102**. More specifically, visual indicator **506** may turn on to indicate that vehicle scanner **106** is presently carrying out communications with at least one electronic control unit (ECU) within the vehicle **102**, and visual indicator **506** may turn off to indicate that vehicle scanner **106** is not presently carrying out communications with at least one ECU within the vehicle **102**.

Visual indicator **508** is an orientation indicator, providing an indicator to a repair technician of the side of the vehicle scanner **106** that the vehicle connector port **600** can be found (See FIG. **6**).

Visual indicators **510** and **514** are communication port activity indicators, and provide an indication of communications activity on the respective Ethernet ports **700** and **702** (See FIG. **7**). Visual indicators **510** and **514** may flash with a periodic intensity relative to a rate of data being communicated over Ethernet ports **700** and **702**. Visual indicator **512** is another communication port activity indicator, but instead provides an indication of communications activity on the USB port **704** (See FIG. **7**). Visual indicator **512** may light up when a USB cable is present and properly connects vehicle scanner **106** to another active device, such as display device **108** or a PDA device. Other methods of providing visual indicators are also possible.

Although not shown, any one of the visual indicators noted above could be replaced by an audio indicator. For example, visual indicator **504** could be replaced with a speaker (or with an audio jack for connecting some other device that converts electrical signals into audio signals) that emits a continuous or periodic audio tone to indicate a corresponding diagnostic or error code.

Grips **516** are arranged along the two longitudinal ends of the vehicle scanner, and may function to keep access port cover **602** (See FIG. **7**) closed and to provide shock absorption in the event that the vehicle scanner **106** is dropped or struck. Grips **516** may be formed as a single piece of rubber connected along a rear or end of the vehicle scanner **106**, or may be formed as two separate pieces of rubber. Materials other than rubber could alternatively be used. Grips **516** may be removed away from the vehicle scanner to open access port cover **602**.

FIG. **6** is a perspective view of the rear face of the vehicle scanner **106** with grips **516** removed and illustrates vehicle interface port **600**, connector mounting holes **601**, access port cover **602**, and upper cover **604**. Port **600** may include a high-density-26 (HD-26) connector, but is not so limited. An HD-26 connector may include 26 male or female connector terminals. Port **600** is arranged to facilitate a wire-line connection to vehicle **102** via wired link **112**. Wired link **112** may comprise a cable that includes fasteners that are arranged to fasten one end of the cable to vehicle scanner **106** via connector mounting holes **601**. The other end of the cable may include similar fasteners to rigidly secure the cable to the vehicle's **102** diagnostic port.

Upper cover **604** may cover, and provide access to when removed, an expansion port that allows the functionality of the vehicle scanner **106** to be upgraded and/or revised. An expansion circuit board may comprise, for example, a printed circuit board (PCB) containing a plurality of discrete circuit elements and/or one or more integrated circuits (ICs). Various expansion circuit boards **1202** may be interfaced with vehicle scanner **106** to provide additional and/or more robust functionality without the need to manufacture an entirely new vehicle scanner **106** device.

FIG. **7** illustrates a vehicle scanner **106** with its access port cover **602** placed in an open position. As set forth in FIG. **7**, access port cover **602** may be hingedly attached to the vehicle scanner **106** via hinges **708** and **710**. Hinges **708** and **710** are rotatable so as to allow port access cover **602** to move from the open position to the closed position and from the closed position to the open position. Channels **720-724** formed in a bottom surface of the vehicle scanner **106** and corresponding channels **726-730** formed in the access port cover **602** form cable openings when access port cover **602** is in the closed position and allow cables to exit the vehicle scanner **106** while the access port cover **602** is in the closed position.

While the access port cover **602** is open, access is provided to Ethernet ports **700** and **702** and to USB port **704**. In alternative embodiments, the ports accessible via access port cover **602** may include a different quantity, or may include different types of ports, including, for example, Firewire and/or eSATA ports. Vehicle scanner **106** may include a respective cable opening for each port accessible via access port cover **602**. Alternatively, one or more cable openings may allow multiple cables to pass through access port cover **602**.

A memory card slot **706** may be provided on a longitudinal side of vehicle scanner **106** and accessible by removing grips **516**. A memory card inserted in memory card slot **706** may provide data storage **408** for vehicle scanner **106**, or may provide removable data storage in addition to separate data storage **408** provided permanently inside vehicle scanner **106**. A memory card for insertion in the memory card slot **706** may include, for example, a Compact Flash card, an SD memory card, a mini SD memory card, an xD card, or other type of memory card. Whether a memory card inserted in memory card slot **706** comprises the data storage **408** or an alternative data store, the memory card may provide CRPI for execution by processor **404** of the vehicle scanner **106**. The removable memory card may also provide storage space for storage of vehicle diagnostic data **416**, in place of data storage device **408**, or in addition to data storage device **408**.

Next, FIG. **8** illustrates a block diagram of diagnostic device **104**, and FIG. **9** illustrates details of an example embodiment of diagnostic device **104**. As illustrated in FIG. **9**, diagnostic device **104** includes a user interface **800**, a wireless transceiver **802**, a processor **804**, an input element **806**, and a data storage device **808**, all of which may be linked together via a system bus, network, or other connection mechanism **810**. As set forth above, diagnostic device **104** may be a DAQ configured to take measurements from the vehicle **102**, including, for example, direct current (DC) voltage readings, alternating voltage (AC) voltage readings, and/or resistance readings. The DAQ **104** may also provide test modes such as a diode test/continuity test mode and a capacitance test mode. Other functions may also be provided.

User interface **800** is operable to present data to a user and to allow a user to enter selections (e.g., mode selections and sub-mode selections). User interface **800** may include a display **900** that is illustrated in FIG. **9**. Display **900** is operable to visually present data, such as data obtained and/or generated by input element **806**, data obtained via wireless transceiver **802**, and/or data contained in data storage device **808**. User interface **800** may include a mode selector for selecting one or more modes and/or sub-modes of DAQ **104**. Example mode selectors **902**, **904**, **906**, **908**, **910**, **912**, **914**, **916**, and **918** are illustrated in FIG. **9**.

Wireless transceiver **802** may comprise a single wireless transceiver that is operable to carry out communications via communications links **114**, **116**. Wireless transceiver **802** may carry out communications with vehicle scanner **106**, display device **108**, and/or some other device that is operating within a wireless communications range of vehicle scanner **106**. As an example, wireless transceiver **802** may comprise a BT transceiver, a Wi-Fi transceiver, or some other type of wireless transceiver.

Alternatively, wireless transceiver **802** may comprise multiple wireless transceivers. For example, wireless transceiver **802** may comprise two wireless transceivers that communicate according to a common air interface protocol or different air interface protocols. Those air interface protocols may be selected from a BT air interface protocol, a Wi-Fi air interface protocol, and some other air interface protocol. In accordance with an embodiment in which wireless transceiver **802** includes two transceivers, a BT transceiver may communicate with vehicle scanner **106** and/or display device **108** via a BT network, and a Wi-Fi transceiver may communicate with vehicle scanner **106** and/or display device **108** via a Wi-Fi network.

Processor **804** may comprise one or more general purpose processors (e.g., INTEL microprocessors) and/or one or more special purpose processors (e.g., digital signal processors). Processor **804** may execute CRPI **818** that are contained in computer-readable data storage device **808**.

Input element **806** may include (i) one or more input leads **812**, (ii) an input signal processing element **814** that is operable to convert input signals obtained via input leads **812** into input data, and (iii) a packet-element **816**. Each input lead **812** is operable to receive input signals from an input signal acquisition point. The input signal acquisition point may comprise any of a variety of locations at which an input signal can be acquired. In accordance with an example, the input signal acquisition point may comprise a location on the vehicle **102** at which a voltage signal, current signal, air pressure signal, air temperature signal, oil pressure signal, oil temperature signal, exhaust composition signal, or some other input signal can be acquired.

Each input lead **812** may include a first end and a second end. The first end of each input lead **812** may be inserted into or otherwise attached to DAQ **104**. The first end of each input lead may comprise a banana plug screw. The second end of each input lead **812** may be arranged in any of a variety of configurations. As an example, a configuration of the second end may comprise a configuration that includes (i) an alligator clip, such as an MTA85 alligator clip sold by Snap-on Incorporated, Kenosha, Wis., United States, (ii) a spring

hook, such as an MTA80 spring hook sold by Snap-on Incorporated, (iii) a test probe, such as an MTA20 test probe sold by Snap-on Incorporated, or (iv) a backprobe, such as an MTTL7005 backprobe sold by Snap-on Incorporated. Other example configurations of the second end of an input lead **812** are also possible.

Input element **806** may include an input signal processing element **814** that is operable to convert an input signal received via one or more input leads **812** into data that is displayable at display **900**. As an example, input signal processing element **814** may include an analog-to-digital converter.

Packet-element **816** may be operable to packetize the input data (e.g., place the input data into data packets) so as to generate data packets containing the input data. Packet-element **816** may provide the data packets to wireless transceiver **802** via connection mechanism **810** for subsequent transmission of the data packets via an air interface. In an alternative embodiment, processor **804** or some other portion of DAQ **104** can comprise packet-element **816** or carry out the functions of packet-element **816**.

Data storage device **808** may comprise a computer-readable storage medium readable by processor **804**. The computer-readable storage medium may comprise volatile and/or non-volatile storage components, such as optical, magnetic, organic or other memory or disc storage, which can be integrated in whole or in part with processor **804**. Data storage device **808** may contain various computer-readable data, such as CRPI **818**, diagnostic device data **820**, input data **822**, and instruction data **824**.

Diagnostic device data **820** may include data associated with a device that is arranged to communicate with DAQ **104** via a wireless network. For example, diagnostic device data **820** may include data associated with display device **108**, such as a radio identifier and password associated with display device **108**. The data associated with display device **108** may be received at DAQ **104**, for storing as diagnostic device data **820**, during a pairing process carried out between display device **108** and DAQ **104**. The pairing process between DAQ **104** and display device **108** may include DAQ **104** providing display device **108** with the data associated with DAQ **104** and display device **108** providing DAQ **104** with data associated with display device **108**. After carrying out the pairing process with display device **108**, DAQ **104** may use the diagnostic device data **820** when establishing communication link **116** with display device **108**.

Diagnostic device data **820** is not limited to data associated with one device. In that regard, diagnostic device data **820** may include respective data associated with each of a plurality of devices, including, for example, data associated with vehicle scanner **106**. The data associated with vehicle scanner **106** may include a radio identifier and password associated with vehicle scanner **106**. The data associated with vehicle scanner **106** may be received at DAQ **104**, for storing as diagnostic device data **820**, during a pairing process carried out between DAQ **104** and vehicle scanner **106**. The pairing process between DAQ **104** and vehicle scanner **106** may include vehicle scanner **106** providing DAQ **104** with the data associated with vehicle scanner **106** and DAQ **104** providing vehicle scanner **106** with data associated with DAQ **104**. After carrying out the pairing process with vehicle scanner **106**, DAQ **104** may use the diagnostic device data **820** when establishing wireless communications link **114** with vehicle scanner **106**.

Input data **822** may comprise data generated by input signal processing element **814**. A portion of data storage device **808** that contains input data **822** may function as a buffer to store input data for display on display **900** and/or for transmission to display device **108** via wireless communications link **116**.

Instruction data **824** may comprise data that identifies how to connect a portion of the DAQ **104** to vehicle **102**, how to operate vehicle **102**, inspections to carry out on vehicle **102**, or some other instruction data. Instruction data **824** may comprise various data including numbers, letters, punctuation marks, pictures, graphs, or some other visually presentable form of data.

CRPI **818** may include program instructions (referred to herein as PI-**818**-A) that are executable to change an operating state of wireless transceiver **802**. Processor **804** may execute PI-**818**-A in response to mode selector **902** (illustrated in FIG. **9**) changing between a local-control mode and a remote-control mode. Execution of PI-**818**-A may cause a transceiver or transceivers of wireless transceiver **802** to transition to a transceiver-on-state in response to mode-selector **902** changing to a remote-control mode from a local-control mode. Similarly, execution of PI-**818**-A may cause a transceiver or transceivers of wireless transceiver **802** to transition to a transceiver-off-state in response to mode-selector **902** changing to a local-control mode from a remote-control mode.

CRPI **818** may also include program instructions (referred to herein as PI-**818**-B) that are executable to determine a desired mode for DAQ **104** responsive to receiving a mode selection command from display device **108**. If DAQ **104** is operating in the desired mode as indicated in the mode selection command, execution of PI-**818**-B allows DAQ **104** to continue operating in the desired mode. On the other hand, if DAQ **104** is operating in a mode different than the desired mode as indicated in the mode selection command, execution of PI-**818**-B causes DAQ **104** to transition to the desired mode.

CRPI **818** may further include program instructions (referred to herein as PI-**818**-C) that are executable to cause display **900** to display instruction data. In one respect, execution of PI-**818**-C may cause display **900** to display instruction data **824** so as to guide a repair technician in connecting input leads **812** to vehicle **102**. In another respect, execution of PI-**818**-C may cause display **900** to display instruction data (such as instruction data **218**) that is received from display device **108** via transceiver **802**.

Next, FIG. **9** illustrates a front view of the example embodiment of DAQ **104**, and in particular, elements of user interface **800** and input element **806**. As set forth above, elements of user interface **800** may include display **900** and mode selectors **902**, **904**, **906**, **908**, **910**, **912**, **914**, **916**, and **918**. Elements of input element **806** may include ports **922**, **924**, and **926**.

Display **900** may comprise a liquid crystal display (LCD), a plasma display, an electrophoretic display, or some other type of display. Display **900** is operable to visually present (e.g., display) data to a repair technician. Display **900** may visually present data using numbers, letters, punctuation marks, pictures, graphs, or some other visually presentable form of data. The data visually presented at display **900** may include locally-acquired data (LAD), such as data acquired via input element **806** (e.g., via input leads **812**) and/or data contained in data storage device **808**. The data visually presented at display **900** may include remotely-acquired data (RAD), such as data acquired via wireless transceiver **802** from one or more of display device **108** and vehicle scanner **106**.

Mode selector **902** comprises a switch having multiple mode-positions. Mode selector **902** may comprise a rotary

switch having nine mode-positions, but is not so limited. Each mode-position of mode selector **902** is associated with one or more modes (e.g., an off mode, a voltmeter mode, an ammeter mode, and a remote control mode, to name a few), and each of the mode-positions may be associated with one or more symbols that identify the mode(s) associated with that mode-position. Table 2 provides an example list of modes associated with each mode-position of mode selector **902**, and an example list of whether each mode is a local-control mode (e.g., a mode selected by mode selector **902**) or a remote-control mode (e.g., a mode selected by display device **108**).

TABLE 2

Mode-position	Mode Control Type	Mode
1	Local-Control	Off
2	Local-Control	DC Voltmeter mode
3	Local-Control	AC Voltmeter mode
4	Local-Control	Ohm-meter mode
5	Local-Control	Diode/Continuity Test mode
6	Local-Control	Auxiliary mode
7	Local-Control	Capacitance mode
8	Local-Control	Oscilloscope mode
9	Remote-Control	Various modes

Mode-position 1 is associated with the symbol "OFF." The mode-position numbers increase in a clockwise direction. The three circles on mode selector **902** are closest to a currently-selected mode position. In FIG. **9**, mode-position 2 (DC Voltmeter mode) is the currently-selected mode-position.

Mode selector **902** may be turned to each of the nine mode-positions. Turning mode selector **902** from a first mode-position (not necessarily mode-position 1) to a second mode-position (not necessarily mode-position 2) causes diagnostic device **104** to transition from a first mode that is associated with the first mode-position to a second mode that is associated with the second mode-position. Transitioning from the first mode to the second mode may be carried out, at least in part, by processor **804** executing program instructions of CRPI **818**.

Transitioning from a local-control mode to a remote-control mode may cause wireless transceiver **802** to transition from the transceiver-off-state to the transceiver-on-state. Processor **804** may execute IP-**818**-A in response to detecting mode selector **902** changing to a remote-control mode from a local-control mode.

Conversely, transitioning from a remote-control mode to a local-control mode may cause wireless transceiver **802** to transition from the transceiver-on-state to the transceiver-off-state. Processor **804** may execute IP-**812**-A in response to detecting mode selector **902** changing to a local-control mode from a remote-control mode.

While mode selector **902** is positioned at a mode-position corresponding to a remote-control mode, wireless transceiver **802** may receive a mode-selection command from display device **108**. The mode-selection command may be unsolicited or may be received in response to wireless transceiver **802** transmitting to display device **108** a request for a mode-selection command. The mode-selection command received at wireless transceiver **802** may include a mode field that identifies a desired local-control mode that is selectable via mode selector **902**. The mode field may also identify a sub-mode that is selectable via one of mode selectors **904**, **906**, **908**, **910**, **912**, **914**, **916**, and **918** when mode selector **902** is in a local-control mode position.

Mode selectors **904**, **906**, **908**, **910**, **912**, **914**, **916**, and **918** may each comprise a respective push button, but are not so limited. Pushing, or pushing and releasing, one of those mode selectors may cause DAQ **104** to transition to a mode and/or sub-mode associated with that mode selector. One or more of mode selectors **904**, **906**, **908**, **910**, **912**, **914**, **916**, and **918** may be associated with multiple modes and/or multiple sub-modes. For example, mode selectors **904**, **906**, **908**, and **910** may be associated with a respective first sub-mode while mode selector **902** positioned at mode-position 2 and may be associated with a second different sub-mode while mode selector **902** is positioned at mode-position 3. One or more of mode selectors **904**, **906**, **908**, **910**, **912**, **914**, **916**, and **918** may be associated with a remote-control mode. For instance, mode selector **904** may associated with a remote-control mode. In that regard, pushing, or pushing and releasing, mode selector **904** may cause DAQ **104** to transition from a local-control mode to a remote-control mode in the same way as if mode selector **902** was moved to mode position 9.

Ports **922**, **924**, and **926** may be operable to receive a respective input lead. Each input lead can include first and second ends. The first end of an input lead may comprise a banana plug. Ports **922**, **924**, and **926** may include a respective female banana connector for receiving the banana plug of an input lead. The second end of each input lead may include an alligator clip, a quick-attach probe, or some other device for contacting an input signal acquisition point.

Grips **928** are arranged along the two longitudinal ends of the DAQ **104**, and provide shock absorption in the event that the DAQ **104** is dropped or struck. Grips **928** may be formed as a single piece of rubber connected along a rear or end of the DAQ **104**, or may be formed as two separate pieces of rubber. Materials other than rubber could alternatively be used.

II. Example Operation

FIG. **10** illustrates a coverage map in accordance with an example system, and FIG. **11** illustrates a process flow that a diagnostic device **104**, **106** may execute in accordance with an embodiment.

As set forth in FIG. **10**, each of display device **108**, diagnostic device **104**, and diagnostic device **106** include a wireless transceiver having a particular transmission range. Although transmission ranges are shown in the shape of a circle in FIG. **10** for ease of illustration, actual transmission range zones will vary in view of obstacles such as walls and in view of other nearby interfering RF devices. Furthermore, and again for ease of description, diagnostic device **104** is illustrated as a DAQ and diagnostic device **106** is illustrated as a vehicle scanner in FIG. **10**. Other arrangements of display devices and diagnostic devices could also be used, and different numbers of display devices **108** and diagnostic devices **104**, **106** could also be used.

Wireless transceiver **202** of display device **108** is illustrated in FIG. **10** as having a transmission range indicated by the dotted circumference **1002**. Wireless transceiver **402** of vehicle scanner **106** is illustrated in FIG. **10** as having a transmission range indicated by the dotted circumference **1004**. Wireless transceiver **802** of DAQ **104** is illustrated in FIG. **10** as having a transmission range indicated by the dotted circumference **1006**.

In the arrangement of FIG. **10**, transmission range **1002** of display device **108** encompasses vehicle scanner **106** but not DAQ **104**. Transmission range **1004** of vehicle scanner **106** encompasses both the display device **108** and DAQ **104**. Transmission range **1006** of DAQ **104** encompasses vehicle scanner **106** but not display device **108**. Other arrangements of devices and transmission ranges are also possible.

Although a particular arrangement is shown in FIG. **10** in which only transceiver **402** of the vehicle scanner **106** is in a position to relay data from one device to another, each respective wireless transceiver **202**, **402**, and **802** may operate to relay communications from one respective device **108**, **106**, and **104** to another in various alternative arrangements of devices, and in other embodiments, may be arranged to relay in such a manner.

In the case of having a single transceiver, data received from one device may be buffered internally prior to transmitting the data to another different device using the same transceiver. In the case of having two or more transceivers, data received from one device on a first transceiver may be routed to a second transceiver for transmission to the another different device concurrently with reception of additional data on the first transceiver. Data frames received from one device may include an immediate medium access control (MAC) destination device of the receiving device, but may contain an ultimate destination address of the another different device embedded or encapsulated within the frame. Processor **204**, perhaps configured by CRPI **212**, may then determine whether a path exists to forward the data to the ultimate destination address of the another different device. If a path exists, the data may be forwarded towards the ultimate destination address via a corresponding wireless transceiver. If a path does not exist, the frame may be dropped, an error message sent back to the source device via a corresponding wireless transceiver, or some other action taken.

Various methods of determining which diagnostic devices are within transmission range of display device **108** may be used. For example, from time to time, and perhaps periodically, a wireless transceiver capable of reaching display device **108** directly, such as the wireless transceiver **402** of the vehicle scanner **106** in FIG. **10**, may transmit a broadcast packet indicating its ability to reach display device **108** directly and to act as a relay agent for display device **108**. Additionally or alternatively, and from time to time, wireless transceiver **402** may receive and respond to a broadcast packet from another diagnostic device, such as DAQ **104**, looking for devices that can reach display device **108**. Other methods could also be used.

FIG. **11** is a flowchart illustrating an exemplary operation **1100** of diagnostic devices **104**, **106** and display device **108**. FIG. **11** is exemplary in nature. Accordingly, although FIG. **11** illustrates a number of steps in a particular order, some steps could be executed in an order different than that set forth in FIG. **11**. Furthermore, additional steps may be added to the operation **1100**. Alternatively, a subset of the steps set forth in operation **1100** may be executed. The set of functions **1100** may be carried out via a custom designed ASIC within one or more of the diagnostic devices **104**, **106** and display device **108**, or may be carried out by one or more of processors **204**, **404**, and **804** executing respective CRPIs that implement the functions of FIG. **11**.

As set forth in step **1102**, a diagnostic device such as DAQ **104** first establishes a wired connection **110** with the vehicle **102** under test and obtains vehicle diagnostic data from the vehicle **102**. The wired connection **110** may be a lead connecting one of ports **922-926** of DAQ **104** with the vehicle **102**, and the vehicle diagnostic data may be, for example, a voltage.

At step **1106**, DAQ **104** determines whether it can directly wirelessly connect with display device **108**. In accordance with the transmission range **1006** shown in the embodiment of FIG. **10**, DAQ **104** can not directly wirelessly connect with display device **108**. DAQ **104** may be unable to directly wirelessly connect with display device **108** for any number of reasons. For example, display device **108** may have been moved outside of DAQ **104**'s transmission range, DAQ **104** may have insufficient transmit power to reach display device **108**, or perhaps another device in the vicinity is producing sufficient interference to reduce the range **1006** of DAQ **104**'s transceiver **802**. In some embodiments, method **1100** may not include step **1106**, but rather may proceed from step **1102** directly to step **1108**.

Next, at step **1108**, DAQ **104** determines whether an indirect connection to display device **108** is available. DAQ **104** may have prior knowledge that an indirect connection to display device **108** is available through vehicle scanner **106** after receiving a broadcast packet from vehicle scanner **106** indicating that it is within range of display device **108** and is available to relay packets to display device **108**. Alternatively, DAQ **104** may transmit its own broadcast packet in step **1108**, or prior to step **1108**, requesting a response from any diagnostic device within its transmission range **1006** that is capable of relaying packets to display device **108**. In response to receiving the broadcast packet, vehicle scanner **106** may reply by transmitting its own broadcast or unicast packet indicating that it is within range of display device **108** and is available to relay packets to display device **108**.

Of course, it is not required that vehicle scanner **106** be wirelessly connected to display device **108**. In one embodiment, vehicle scanner **106** may be connected to display device **108** via its wired interface **406**, which may include, for example, a USB connection and/or an Ethernet connection. In the same way as above, vehicle scanner **106** may broadcast its ability to relay packets to display device **108** via its wired interface **406**. Packets received via wireless transceiver **402** may then be routed over bus **410** to wired interface **406** and relayed to display device **108** over a wired connection via wired interface **406**.

The exchange of information between diagnostic devices **104** and **106** may also include additional information, such as battery source and/or battery power remaining. For example, in the event that vehicle scanner **106** is operating off of an external power source such as vehicle **102**'s battery, it may so indicate to DAQ **104** in a broadcast or unicast packet. Alternatively, in the event that vehicle scanner **106** is operating off of local battery power, it may so indicate to DAQ **104** in a broadcast or unicast packet, and may further indicate an estimated amount of battery power remaining.

In step **1110**, DAQ **104** determines the best route to display device **108**. In the event that only one of a direct wireless connection and an indirect wireless connection to display device **108** is available, DAQ **104** uses the one available connection. This may include a situation where DAQ **104** determines that a prior available direct connection with display device **108** has been interrupted. Responsive to detecting the interruption, DAQ **104** routes data indirectly to display device **108** via an indirect connection. Subsequently, responsive to determining that the direct wireless connection with the display device **108** has been restored, DAQ **104** may stop transmitting data via the indirect wireless connection and start transmitting data to display device **108** via the direct wireless connection.

As shown in FIG. **10**, a direct wireless connection between DAQ **104** and display device **108** is not available due to transmission range limitations of the DAQ's **104** transceiver **802**. Therefore, the only path to route obtained vehicle diagnostic data to display device **108** is via vehicle scanner **106**, where vehicle scanner **106** acts as a relay agent to route the vehicle diagnostic data to the display device **108** on behalf of the DAQ **104**.

In an alternative embodiment, and in the event that transmission range **1006** of DAQ **104** reaches both vehicle scanner **106** and display device **108**, DAQ **104** may take into account additional considerations in determining a best route to display device **108**. For example, DAQ **104** may take into account the relative transmission power required to transmit directly to display device **108** and to transmit indirectly to vehicle scanner **106**, and then transmit to the device that requires a lower transmission power.

Required transmission power could be determined in a number of ways. For example, DAQ **104** may transmit a packet requiring an acknowledgment to each of the display device **108** and the vehicle scanner **106** at ever increasing transmission power levels until the DAQ **104** receives an ACK frame from the respective device. The point at which an acknowledgment frame is received may provide an indication of a transmission power level needed to reach the display device **108**.

Alternatively, DAQ **104** may receive a packet from each of display device **108** and the vehicle scanner **106** that includes an indication of the power level that each packet was transmitted at. By measuring the power level of the received packet and the indication of the power level at which the packet was transmitted, DAQ **104** can make a determination of a transmission power level needed to reach each of the respective display device **108** and DAQ **104**. Other methods of calculating required transmission power levels could also be used.

An additional consideration that DAQ **104** may take into account is respective battery power source types and levels. For example, if DAQ **104** is running on battery power and DAQ **104** determines that vehicle scanner **106** is running on an external power source such as vehicle **102**'s battery, DAQ **104** may determine that the best route to display device **108** is through a shorter transmission path to vehicle scanner **106**. This embodiment saves battery power at the DAQ **104** by utilizing the external power source available at vehicle scanner **106** to complete the transmission to display device **108**.

Alternatively, if DAQ **104** determines that vehicle scanner **106** is also operating on a local battery power source, DAQ **104** may use relative battery power level information to determine the best route to display device **108**. For example, if DAQ **104** is provided with battery level information from vehicle scanner **106** indicating that vehicle scanner **106**'s battery power level is at 50%, and DAQ **104** knows its own battery power level is at 90%, it may determine that the best route is to transmit directly to display device **108** despite the fact that a higher transmission power level will be required than to transmit indirectly via vehicle scanner **106**. Assuming that the relative battery power levels are switched, and DAQ **104** knows its own battery power level is at 50% and the vehicle scanner **106** is operating on battery power having a power level at 90%, DAQ **104** may determine that the best route is to transmit indirectly via vehicle scanner **106**. This embodiment saves battery power at the DAQ **104** by utilizing the higher battery power level available at vehicle scanner **106** to complete the transmission to display device **108**.

At step **1112**, DAQ **104** transmits the obtained vehicle diagnostic data via the determined best route. In the case of FIG. **10**, the determined best route is to transmit the vehicle diagnostic data to the display device **108** indirectly via the vehicle scanner **106** because that is the only route available. In other embodiments, and based on additional considerations and/or various re-arrangements of diagnostic devices, the determined best route could be an indirect or a direct wireless connection to display device **108**, and could involve one or more intermediate relay devices.

While FIG. **11** is directed to a transmission of vehicle diagnostic data from a diagnostic device **104**, **106** to a display device **108**, any and all of the principles described above could just as well be applied in the opposite direction, e.g., transmissions of commands, instructions, and/or data from display device **108** to diagnostic devices **104**, **106**.

FIG. **12** describes an example flow of diagnostic communications from display device **108** to a first one of the diagnostic devices **104**, **106**. For example, in the arrangement shown in FIG. **10**, if display device **108** wishes to take control of DAQ **104** and place DAQ **104** in a remote control mode, it may do so via an indirect transmission of a control command to DAQ **104** relayed through vehicle scanner **106**. Although the DAQ **104** is used as a destination device for ease of illustration with respect to FIG. **10**, in other embodiments, display device **108** may transmit commands and/or data to vehicle scanner **106** via DAQ **104**.

The process flow **1200** set forth in FIG. **12** describes in more detail how display device may transmit diagnostic communications to a destination diagnostic device, for example DAQ **104** in FIG. **10**, via a relay diagnostic device, for example, vehicle scanner **106** in FIG. **10**. FIG. **12** is exemplary in nature. Accordingly, although FIG. **12** illustrates a number of steps in a particular order, some steps could be executed in an order different than that set forth in FIG. **12**. Furthermore, additional steps may be added to the operation **1200**. Alternatively, a subset of the steps set forth in operation **1200** may be executed. The set of functions **1200** may be carried out via a custom designed ASIC within the display device **108**, or may be carried out by one or more of processors **204** executing respective CRPIs that implement the functions of FIG. **12**.

As set forth in step **1202**, display device **108** first detects a command and/or data destined for a first diagnostic device, such as DAQ **104** in FIG. **10**. The command may be, for example, a command requesting to begin remote control of DAQ **104**, or may be data for display on the display **900** of DAQ **104** illustrating where to connect one of particular leads having their second end connected to one or more of ports **922**, **924**, and **926**. Other types of diagnostic communications could be transmitted as well.

At step **1206**, display device **108** determines whether it can directly wirelessly connect with DAQ **104**. In accordance with the transmission range **1002** shown in the embodiment of FIG. **10**, display device **108** can not directly wirelessly connect with display device **108**. Display device **108** may be unable to directly wirelessly connect with DAQ **104** for any number of reasons. For example, DAQ **104** may have been moved outside of display device's **108** transmission range, display device **108** may have insufficient transmit power to reach DAQ **104**, or perhaps another device in the vicinity is producing sufficient interference to reduce the range **1002** of display device's **108** transceiver **202**. In some embodiments, method **1200** may not include step **1206**, but rather may proceed from step **1202** directly to step **1208**.

Next, at step **1208**, display device **108** determines whether an indirect connection to DAQ **104** is available. Display device **108** may have prior knowledge that an indirect connection to DAQ **104** is available through vehicle scanner **106** after receiving a broadcast packet from vehicle scanner **106** indicating that it is within range of DAQ **104** and is available to relay packets to DAQ **104**. Alternatively, display device **108** may transmit its own broadcast packet in step **1208**, or prior to step **1208**, requesting a response from any diagnostic device within its transmission range **1002** that is capable of relaying packets to DAQ **104**. In response to receiving the broadcast packet, vehicle scanner **106** may reply by transmit-

ting its own broadcast or unicast packet indicating that it is within range of DAQ **104** and is available to relay packets to DAQ **104**.

The exchange of information between display device **108** and vehicle scanner **106** may also include additional information, such as battery source and/or battery power remaining. For example, in the event that vehicle scanner **106** is operating off of an external power source such as vehicle **102**'s battery, it may so indicate to display device **108** in a broadcast or unicast packet. Alternatively, in the event that vehicle scanner **106** is operating off of local battery power, it may so indicate to display device **108** in a broadcast or unicast packet, and may further indicate an estimated amount of battery power remaining.

In step **1210**, display device **108** determines the best route to DAQ **104**. In the event that only one of a direct wireless connection and an indirect wireless connection to DAQ **104** is available, display device **108** uses the one available connection. This may include a situation where display device **108** determines that a prior available direct connection with DAQ **104** has been interrupted. Responsive to detecting the interruption, display device **108** routes data indirectly to DAQ **104** via an indirect connection. Subsequently, responsive to determining that the direct wireless connection with the DAQ **104** has been restored, display device **108** may stop transmitting data via the indirect wireless connection and start transmitting data to DAQ **104** via the direct wireless connection.

As shown in FIG. **10**, a direct wireless connection between DAQ **104** and display device **108** is not available due to transmission range limitations of the display device's **108** transceiver **202**. Therefore, the only path to route diagnostic communications to DAQ **104** is via vehicle scanner **106**, where vehicle scanner **106** acts as a relay agent to route the diagnostic communications to the display device **108** on behalf of the display device **108**.

In an alternative embodiment, and in the event that transmission range **1002** of display device **108** reaches both vehicle scanner **106** and DAQ **104**, display device **108** may take into account additional considerations in determining a best route to DAQ **104**. For example, display device **108** may take into account the relative transmission power required to transmit directly to DAQ **104** and to transmit indirectly via vehicle scanner **106**, and then transmit to the device that requires a lower transmission power.

Required transmission power could be determined in a number of ways. For example, display device **108** may transmit a packet requiring an acknowledgment to each of the DAQ **104** and the vehicle scanner **106** at ever increasing transmission power levels until the display device **108** receives an ACK frame from the respective device. The point at which an acknowledgment frame is received may provide an indication of a transmission power level needed to reach the diagnostic devices.

Alternatively, display device **108** may receive a packet from each of DAQ **104** and the vehicle scanner **106** that includes an indication of the power level that each packet was transmitted at. By measuring the power level of the received packet and the indication of the power level at which the packet was transmitted, display device **108** can make a determination of a transmission power level needed to reach each of the respective vehicle scanner **106** and DAQ **104**. Other methods of calculating required transmission power levels could also be used.

An additional consideration that display device **108** may take into account is respective battery power source types and levels. For example, if display device **108** is running on battery power and display device **108** determines that vehicle scanner **106** is running on an external power source such as vehicle **102**'s battery, display device **108** may determine that the best route to display device **108** is through a shorter transmission path to vehicle scanner **106**. This embodiment saves battery power at the display device **108** by utilizing the external power source available at vehicle scanner **106** to complete the transmission to DAQ **104**.

Alternatively, if display device **108** determines that vehicle scanner **106** is also operating on a local battery power source, display device **108** may use relative battery power level information to determine the best route to DAQ **104**. For example, if display device **108** is provided with battery level information from vehicle scanner **106** indicating that vehicle scanner **106**'s battery power level is at 50%, and display device **108** knows its own battery power level is at 90%, it may determine that the best route is to transmit directly to DAQ **104** despite the fact that a higher transmission power level will be required than to transmit indirectly via vehicle scanner **106**. Assuming that the relative battery power levels are switched, and display device **108** knows its own battery power level is at 50% and the vehicle scanner **106** is operating on battery power having a power level at 90%, display device **108** may determine that the best route is to transmit indirectly via vehicle scanner **106**. This embodiment saves battery power at the display device **108** by utilizing the higher battery power level available at vehicle scanner **106** to complete the transmission to DAQ **104**.

At step **1212**, display device **108** transmits the detected command and/or data to DAQ **104** via the determined best route. In the case of FIG. **10**, the determined best route is to transmit the detected command and/or data to the DAQ **104** indirectly via the vehicle scanner **106** because that is the only route available. In other embodiments, and based on additional considerations and/or various re-arrangements of diagnostic devices, the determined best route could be an indirect or a direct wireless connection to DAQ **104**, and could involve one or more intermediate relay devices.

Display device **108** may receive power via a local battery source, an AC adapter, or some other source. In an embodiment in which the transceiver **202** of display device **108** has a transmission range **1002** that extends to cover both the vehicle scanner **106** and DAQ **104**, display device **108** may take into consideration its own power status and the power status of vehicle scanner **106** in transmitting commands and/or data to DAQ **104**. For example, if display device **108** detects that it is operating on external power via an AC adapter, it may determine that the best route to DAQ **104** is to wirelessly transmit commands and/or data directly to DAQ **104**, regardless of the power status of vehicle scanner **106**. On the other hand, if display device **108** is operating off of a local battery power source, it may obtain power status information from vehicle scanner **106** prior to determining a best route to DAQ **104** and take the power status into consideration in determining the best route.

For example, if display device **108** is provided with battery level information from vehicle scanner **106** indicating that its battery power level is at 50%, and display device **108** knows its own battery power level is at 90%, it may determine that the best route is to transmit directly to DAQ **104** despite the fact that a higher transmission power level will be required than to transmit indirectly via vehicle scanner **106**. Assuming that the relative battery power levels are switched, and display device **108** knows its own battery power level is at 50% and the vehicle scanner **106** is operating on battery power having a power level at 90%, display device **108** may determine that the best route is to transmit indirectly via vehicle scanner **106**. This embodiment saves battery power at the display device

108 by utilizing the higher battery power level available at vehicle scanner 106 to complete the transmission to DAQ 104.

III. Conclusion

Example embodiments of the present invention have been described above. Those skilled in the art will understand that changes and modifications may be made to the described embodiments without departing from the true scope and spirit of the present invention, which is defined by the claims.

We claim:

1. A method performed by a diagnostic device, the method comprising:
- determining that a direct wireless connection between the diagnostic device and a display device is available and that an indirect wireless connection between the diagnostic device and the display device is available using a diagnostic apparatus as an intermediary;
- determining that the diagnostic device is consuming power provided by a first battery of the diagnostic device and that the diagnostic apparatus is consuming power provided by a second battery of the diagnostic apparatus;
- receiving vehicle data from a vehicle under test;
- receiving, from the diagnostic apparatus, a communication indicating a second battery level of the second battery;
- determining whether a first battery level of the first battery is greater than the second battery level based on the indicated second battery level;
- selecting either the direct wireless connection or the indirect wireless connection for transmitting the received vehicle data to the display device based on determining whether the first battery level of the first battery is greater than the second battery level of the second battery; and
- transmitting, to the display device, the received vehicle data using the selected wireless connection.

2. The method of claim 1, further comprising:
- determining that the first battery level is greater than the second battery level,
- wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting the direct wireless connection.

3. The method of claim 1, further comprising:
- determining that the second battery level is greater than the first battery level,
- wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting the indirect wireless connection.

4. The method of claim 1, further comprising:
- determining that a first transmission power level required to transmit the vehicle data to the display device using the direct wireless connection is less than a second transmission power level required to transmit the vehicle data to the display deice using the indirect wireless connection,
- wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting the direct wireless connection based on determining that the first transmission power level is less than the second transmission power level.

5. The method of claim 1, further comprising:
- determining that a second transmission power level required to transmit the vehicle data to the display device using the indirect wireless connection is less than a first transmission power level required to transmit the vehicle data to the display device using the direct wireless connection,
- wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting the indirect wireless connection based on determining that the second transmission power level is less than the first transmission power level.

6. The method of claim 1, further comprising:
- transmitting to the diagnostic apparatus and the display device at iteratively increasing transmission power levels until the diagnostic device receives an acknowledgment from the diagnostic apparatus and an acknowledgment from the display device;
- determining a second transmission power level required to transmit the vehicle data to the display device using the indirect wireless connection after the diagnostic device receives the acknowledgment from the diagnostic apparatus; and
- determining a first transmission power level required to transmit the vehicle data to the display device using the direct wireless connection after the diagnostic device receives the acknowledgment from the display device
- wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting either the direct wireless connection or the indirect wireless connection based on the determined first transmission power level and the determined second transmission power level.

7. The method of claim 1, further comprising:
- receiving, from the diagnostic apparatus, a first indication of a first received power level at which the diagnostic apparatus received a packet transmitted by the diagnostic device,
- receiving, from the display device, a second indication of a second received power level at which the display device received a packet transmitted by the diagnostic device, and
- determining, using the first indication and the second indication, a first transmission power level required to transmit the vehicle data to the display device using the direct wireless connection and a second transmission power level required to transmit the vehicle data to the display device using the indirect wireless connection,
- wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting either the direct wireless connection or the indirect wireless connection based on the determined first transmission power level and the determined second transmission power level.

8. A diagnostic device comprising:
- a processor; and
- a non-transitory computer-readable medium storing program instructions executable by the processor to cause the diagnostic device to perform functions comprising:
- determining that a direct wireless connection between the diagnostic device and a display device is available and that an indirect wireless connection between the diagnostic device and the display device is available using a diagnostic apparatus as an intermediary;
- determining that the diagnostic device is consuming power provided by a first battery of the diagnostic device and that the diagnostic apparatus is consuming power provided by a second battery of the diagnostic apparatus;
- receiving vehicle data from a vehicle under test;
- receiving, from the diagnostic apparatus, a communication indicating a second battery level of the second battery;

determining whether a first battery level of the first battery is greater than the second battery level based on the indicated second battery level;

selecting either the direct wireless connection or the indirect wireless connection for transmitting the received vehicle data to the display device based on determining whether the first battery level of the first battery is greater than the second battery level of the second battery; and

transmitting, to the display device, the received vehicle data using the selected wireless connection.

9. The diagnostic device of claim **8**, wherein the functions further comprise:

determining that the first battery level is greater than the second battery level,

wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting the direct wireless connection.

10. The diagnostic device of claim **8**, wherein the functions further comprise:

determining that the second battery level is greater than the first battery level,

wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting the indirect wireless connection.

11. The diagnostic device of claim **8**, wherein the functions further comprise:

determining that a first transmission power level required to transmit the vehicle data to the display device using the direct wireless connection is less than a second transmission power level required to transmit the vehicle data to the display device using the indirect wireless connection,

wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting the direct wireless connection based on determining that the first transmission power level is less than the second transmission power level.

12. The diagnostic device of claim **8**, wherein the functions further comprise:

determining that a second transmission power level required to transmit the vehicle data to the display device using the indirect wireless connection is less than a first transmission power level required to transmit the vehicle data to the display device using the direct wireless connection,

wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting the indirect wireless connection based on determining that the second transmission power level is less than the first transmission power level.

13. The diagnostic device of claim **8**, wherein the functions further comprise:

transmitting to the diagnostic apparatus and the display device at iteratively increasing transmission power levels until the diagnostic device receives an acknowledgment from the diagnostic apparatus and an acknowledgment from the display device;

determining a second transmission power level required to transmit the vehicle data to the display device using the indirect wireless connection after the diagnostic device receives the acknowledgment from the diagnostic apparatus; and

determining a first transmission power level required to transmit the vehicle data to the display device using the direct wireless connection after the diagnostic device receives the acknowledgment from the display device,

wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting either the direct wireless connection or the indirect wireless connection based on the determined first transmission power level and the determined second transmission power level.

14. The diagnostic device of claim **8**, wherein the functions further comprise:

receiving, from the diagnostic apparatus, a first indication of a first received power level at which the diagnostic apparatus received a packet transmitted by the diagnostic device,

receiving, from the display device, a second indication of a second received power level at which the display device received a packet transmitted by the diagnostic device, and

determining, using the first indication and the second indication, a first transmission power level required to transmit the vehicle data to the display device using the direct wireless connection and a second transmission power level required to transmit the vehicle data to the display device using the indirect wireless connection,

wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting either the direct wireless connection or the indirect wireless connection based on the determined first transmission power level and the determined second transmission power level.

15. A non-transitory computer-readable medium storing program instructions executable by a diagnostic device to cause the diagnostic device to perform functions comprising:

determining that a direct wireless connection between the diagnostic device and a display device is available and that an indirect wireless connection between the diagnostic device and the display device is available using a diagnostic apparatus as an intermediary;

determining that the diagnostic device is consuming power provided by a first battery of the diagnostic device and that the diagnostic apparatus is consuming power provided by a second battery of the diagnostic apparatus;

receiving vehicle data from a vehicle under test;

receiving, from the diagnostic apparatus, a communication indicating a second battery level of the second battery;

determining whether a first battery level of the first battery is greater than the second battery level based on the indicated second battery level;

selecting either the direct wireless connection or the indirect wireless connection for transmitting the received vehicle data to the display device based on determining whether the first battery level of the first battery is greater than the second battery level of the second battery; and

transmitting, to the display device, the received vehicle data using the selected wireless connection.

16. The non-transitory computer-readable medium of claim **15**, wherein the functions further comprise:

determining that the first battery level is greater than the second battery level,

wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting the direct wireless connection.

17. The non-transitory computer-readable medium of claim **15**, wherein the functions further comprise:

determining that the second battery level is greater than the first battery level,

wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting the indirect wireless connection.

18. The non-transitory computer-readable medium of claim **15**, wherein the functions further comprise:

determining that a first transmission power level required to transmit the vehicle data to the display device using the direct wireless connection is less than a second transmission power level required to transmit the vehicle data to the display device using the indirect wireless connection,

wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting the direct wireless connection based on determining that the first transmission power level is less than the second transmission power level.

19. The non-transitory computer-readable medium of claim **15**, wherein the functions further comprise:

determining that a second transmission power level required to transmit the vehicle data to the display device using the indirect wireless connection is less than a first transmission power level required to transmit the vehicle data to the display device using the direct wireless connection,

wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting the indirect wireless connection based on determining that the second transmission power level is less than the first transmission power level.

20. The non-transitory computer-readable medium of claim **15**, wherein the functions further comprise:

transmitting to the diagnostic apparatus and the display device at iteratively increasing transmission power levels until the diagnostic device receives an acknowledgment from the diagnostic apparatus and an acknowledgment from the display device;

determining a second transmission power level required to transmit the vehicle data to the display device using the indirect wireless connection after the diagnostic device receives the acknowledgment from the diagnostic apparatus; and

determining a first transmission power level required to transmit the vehicle data to the display device using the direct wireless connection after the diagnostic device receives the acknowledgment from the display device,

wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting either the direct wireless connection or the indirect wireless connection based on the determined first transmission power level and the determined second transmission power level.

21. The non-transitory computer-readable medium of claim **15**, wherein the functions further comprise:

receiving, from the diagnostic apparatus, a first indication of a first received power level at which the diagnostic apparatus received a packet transmitted by the diagnostic device,

receiving, from the display device, a second indication of a second received power level at which the display device received a packet transmitted by the diagnostic device, and

determining, using the first indication and the second indication, a first transmission power level required to transmit the vehicle data to the display device using the direct wireless connection and a second transmission power level required to transmit the vehicle data to the display device using the indirect wireless connection,

wherein selecting either the direct wireless connection or the indirect wireless connection comprises selecting either the direct wireless connection or the indirect wireless connection based on the determined first transmission power level and the determined second transmission power level.

* * * * *